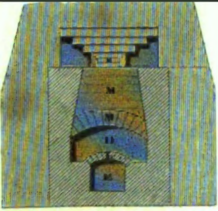

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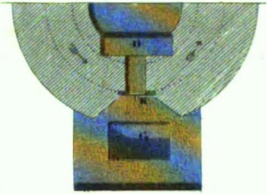

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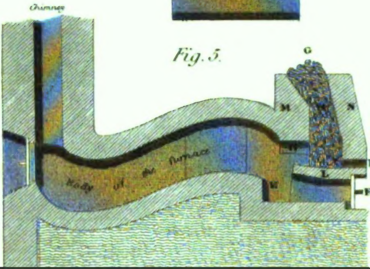

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John Redman Coxe, Thomas Cooper

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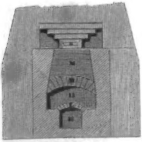
Fig. 2.



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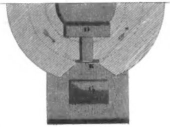

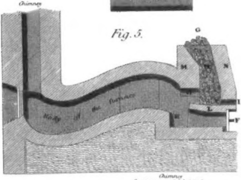

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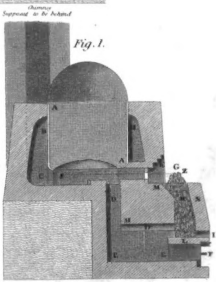
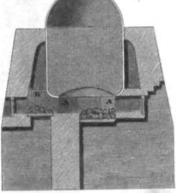


Fig. 1.

Fig. 6.



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THE

EMPORIUM

OF

ARTS AND SCIENCES.

VOL. II.] DECEMBER, 1813. [No. I.

AN ACCOUNT OF THE STEAM ENGINE.

For the purposes of this article, I have consulted the following essays.

1st. The articles steam, and steam engine, in the old Edinburgh Encyclopedia, republished in this country by Dobson. I believe these articles were drawn up by Professor Robison, of Edinburgh, and are well executed. As this work is common in America, I have not chosen to copy these articles, but I earnestly recommend them to the careful (not the perusal, but) study of the reader who wishes to become acquainted with this subject. In studying these articles, care must be taken to refer to the additions made in the supplement to that Encyclopedia, under the head of „ Steam engine."

2dly. An account of steam engines, by Olinthus Gregory, the compiler of Gregory's Encyclopedia, a work for the most part too brief and superficial to communicate valuable knowledge: but the mechanical articles are tolerably well executed, it being a subject to which he had much attended. The account of steam engines is extracted from his treatise on mechanics, theoretical, practical and descriptive. Second edition, 1807. The arti-

cle is chiefly drawn up by Mr. J. C. Hornblower, who had a law suit with Mr. James Watt, of Birmingham, wherein the latter was plaintiff, on the subject of infringing the patent right of Mr. Watt. Mr. Hornblower was cast. The article in Gregory, is drawn up with so much illiberality of remark on the pretensions of Mr. James Watt, and on the article in the Edinburgh Encyclopedia above referred to, that I have been able to make a few extracts only from it, for the use of the Emporium. This tract of Gregory's induced

3dly. A review of Gregory's account steam engines, in the 26th number of the Edinburgh Review, for January 1809. This very able and very severe article, I have been given to understand, was written by Professor Playfair, of Edinburgh, whose very brief but very neat account of the history of steam engines, I shall extract.

4thly. I have consulted, and shall use, Nicholson's account of Watt's steam engine in his 8vo. Encyclopedia; a work, written under the pressure of straitened circumstances, and therefore not with the usual care of this most useful and industrious man.

5thly. I have consulted the following articles on the subject in Nicholson's Journal, viz. 1 V. 419. 2 V. 46 228. 364. 476. 3 V. 86. 161. 4 V. 545. 5 V. 147. of the quarto edition. Of the 8vo. series, 1 V. 161. 2 V. 68. 6 V. 218. 249. 7 V. 310. 8 V. 169. 262. 11 V. 93. 243. 12 V. 1. 174. 294. 316. 17 V. 5. 18 V. 260. And the following articles in that collection on horse power, 9 V. 214. 11 V. 96. 98. 145. 264. 271.

I have also consulted the articles giving an account of Cartwright's, Trevethic's, and Woolfe's improvements on Watt's engine in Tilloch's Philosophical Magazine, wherein the articles relating to the steam engines, are to be found in 1 V. 1. 16 V. 372. 17 V. 40. 164. 19

V. 133. 275. 21 V. 254. 23 V. 123. 335. 26 V. 316.

As there is no general index to these works, I apprehend it will be useful to note the places where information on this subject can be found in them.

The common histories of the steam engine, include a description of Savary's, Newcomen's and Cawley's, and Watt's. I shall add, some account of the improvements of Hornblower, Cartwright, and Woolfe. Also, Oliver Evans's account of his steam engine. I do not know that I can get all the plates ready for the present number, but I shall insert herein the methods of consuming smoke, because those plates are likely to be completed in time.

On the means of CONSUMING THE SMOKE, *arising from large furnaces, particularly from steam engines.*

I would premise, that smoke, is a mixture of aqueous vapour—charcoal—and carburetted hydrogen, distilled off by means of heat from fuel.

When a candle or a lamp burns in the common method, they smoke. That is, the fuel instead of being burnt or consumed, is in part distilled away by the heat: for as there can be no combustion but by means of the oxygen of the atmospheric air, and as the outside only of the wick is in contact with the air, the fuel with which the outside is impregnated, only can be burnt: the oil or tallow of the inside, is distilled away and forms the smoke. Part of this is caught and inflamed as it escapes into the air; hence the flame of a candle extends beyond the point of the wick; but the whole of it is not burnt. What is not burnt is smoke.

To remedy this M. D'Argand, the inventor of the patent lamp, has contrived (by making the wick *thin*, and *circular*, and by admitting a current of air to both sides of the wick) to consume the whole of the fuel by supplying every part of it with atmospheric air in a strong cur-

rent occasioned by the rarefaction produced in the glass chimney. That this is a true account of the process, any one may satisfy himself, by closing the apertures of the grating at the bottom of the lamp, through which the air ascends up the chimney ; and the wick no longer supplied with the oxygen of the atmosphere, will send off the combustible oil, unburnt in the form of smoke like a common lamp.

If a piece of wood be distilled, it furnishes an acidulous watery liquor, a large quantity of carburetted hydrogen gas, that is charcoal dissolved in hydrogen gas, and its own bulk of charcoal. Both the hydrogen gas and the charcoal, are combustible *with* access of air, but incombustible without it. The flame of a wood fire, is owing to the ascension of the carburetted hydrogen distilled off from the wood. The smoke is partly acidulous vapour, and partly unconsumed carburetted hydrogen.

Whatever is capable of being burnt gives out heat : for the oxygen of the atmosphere, when it combines with a combustible body, parts with the heat to which it is chemically united. That heat, becomes sensible, and acts upon the bodies around. The smoke attaches itself to the bodies it meets with, and sticks to them, and a quantity of carbon or charcoal is deposited : this mixture is called Soot.

When a quantity of coal is set on fire the same process takes place ; a tar-acid vapour flies off mixed with carburetted hydrogen holding much carbon or charcoal in solution ; this is the smoke, which when condensed in the chimney or on the bottom of a boiler, forms also soot ; thicker, and containing more carbon, and volatile oil than the soot of wood.

Four ounces avoirdupois of pine saw dust, yielded me 12 quarts of carburetted hydrogen. The same weight of bituminous Liverpool coal, yielded me 18 quarts. Some

coal would yield 24 quarts. Soot then consists chiefly of unburnt charcoal.

Take out of the fire, a piece of charcoal about an inch or half an inch long, well lighted at one end. You may hold it in your fingers, and even excite by blowing, the lighted end, without being burnt. *Charcoal therefore is a very bad conductor of heat.* Take a piece of iron or brass, a foot long, and holding it at one end, thrust the other into the fire. Long before it approaches a red heat, your fingers will be burnt. *Metals therefore are very good conductors of heat.* Hence, when we suffer soot to accumulate at the bottom of our boilers, we exchange a very good for a very bad conductor of heat; and we must employ more fuel, for the purpose of communicating the same heat to the water. Hence it is a point of economy to consume the smoke under the boiler of a steam engine.

The method of consuming the smoke of furnaces, depends upon two principles: 1st. the vivid, well-lighted coals, are pushed forward, and the half lighted coals are not thrown upon or beyond them promiscuously, but placed at that part of the fire, where the body of vivid coals commences: hence the smoke arising from the half-lighted, can be made to pass over the lighted coals. But the smoke would rise up, if it were not, 2ly. that a current of air is admitted, and directed downward, so as to drive the rising smoke upon and over the surface of the red hot coals, where it is burnt and consumed as fuel.

Suppose the door frame of the fire place, shuts against a platform, not *level* with the fire as usually is the case, but raised above the burning fuel, &c. slanting downward from the inside of the door toward the fire; so that the coals can be easily pushed inward to any part of the fire; if then, there be a slit of an inch wide for instance, across the door, a current of air will pass through that slit over the fire in addition to the current of air that passes upwards

through the bars and among the fuel. By means of a piece of sheet iron placed slanting over the slit within-side, this current of air through the slit in the door, can be directed so as to drive the smoke of the fresh coals, down upon the burning coals, and there it will be consumed.

The three following methods, which can be well understood from the plates, have long been in use in England, and therefore can be employed for the purpose of consuming smoke as well here as there.

In the year 1791, the steam engines on Watt's construction at Manchester, consumed the smoke: the public complained that no method was adopted by the owners of other steam engines, and by the dyers in and near that town, to produce the same effect in their furnace-fires. I applied to Boulton and Watt, and obtained permission for any person to use their patent in this respect, whether connected with one of their engines or not. Of course the smoke of the furnaces was consumed generally, on paying a moderate premium for the use of the invention.

Several furnaces however were erected from time to time, and steam engines already put up previous to the improvements of Boulton and Watt, were worked with furnaces, which were not built on a construction necessary to consume the smoke. In the Monthly Magazine for 1796, the reader will find an account of six owners of steam engines and furnaces at Manchester, who were indicted at the quarter sessions for a nuisance, inasmuch as they did not use means to consume the smoke of their furnaces: they were convicted, and fined *one hundred pounds sterling each;* and the conviction was acquiesced in. I have no hesitation in saying that the neglect of employing such means, is just as much a nuisance in this country as in that. I now publish in a manner not to be mistaken, the methods of producing this effect; one or

other of which is in common use in Great-Britain, and either of which will answer the purpose. A steam engine of the power of a dozen horses, need not, and ought not, to send forth so much smoke as a common sitting room fire: the method of producing this effect, is not a tax upon the owner, but an advantage; for he consumes his fuel more perfectly, and none goes to waste. If steam engines continue to be erected in large towns, without having this improvement attached to them, instead of being as they might be, blessings to the neighbourhood, they will make our towns uninhabitable; and I would earnestly recommend that the legal question of *nuisance* should be settled, by an indictment brought against the offenders.

Specification of the Patent granted to Mr. JAMES WATT, *of Birmingham, in the County of Warwick, Engineer; for certain newly-improved Methods of constructing Furnaces or Fire-places, for heating, boiling, or evaporating of water, and other Liquids; which are applicable to steam-engines and other purposes; and also for heating, melting, and smelting, of Metals, and their Ores; whereby greater effects are produced from the Fuel, and the smoke is in a great measure prevented, or consumed.*

Dated, June 14, 1785.

TO all to whom these presents shall come, &c. NOW KNOW YE, that, in compliance with the said proviso, and in pursuance of the said statute, I the said James Watt, do hereby declare, that the following is a particular description of the nature of my said invention, and in what manner the same is to be performed; that is to say, my said newly-improved methods of constructing furnaces or fire-places consist in causing the smoke or flame of the

fresh fuel, in its way to the flues or chimney, to pass, together with a current of fresh air, through, over, or among, fuel which has already ceased to smoke, or which is converted into cokes, charcoal, or cinders, and which is intensely hot ; by which means the smoke and grosser parts of the flame, by coming into close contact with, or by being brought near unto, the said intensely hot fuel, and by being mixed with the current of fresh or unburnt air, are consumed, or converted into heat, or into pure flame free from smoke. I put this in practice, first, by stopping up every avenue or passage to the chimney or flues, except such as are left in the interstices of the fuel, by placing the fresh fuel above, or nearer to, the external air than that which is already converted into cokes or charcoal ; and by constructing the fire-places in such manner that the flame, and the air which animates the fire, must pass downwards, or laterally, or horizontally, through the burning fuel, and pass from the lower part, or internal end or side, of the fire-place, to the flues or chimney. In some cases, after the flame has past through the burning fuel, I cause it to pass through a very hot funnel, flue, or oven, before it comes to the bottom of the boiler, or to the part of the furnace where it is proposed to melt metal, or perform other office, by which means the smoke is still more effectually consumed. In other cases, I cause the flame to pass immediately from the fire-place into the space under a boiler, or into the bed of a melting or other furnace. The drawing Figure 1 (Plate I.) shews a section of a fire-engine boiler, and its furnace or fire-place, which I have chosen for an example of the application of this new method to the heating and evaporating of water. A A is the boiler, which may be made of any form suitable to its use. B B is a flue, surrounding the boiler as usual. C is the uptake, or passage from the space under the boiler to the flues. D D is a funnel or flue for the flame to

come from the fire-place to the boiler. E E is a place to contain the ashes; and F is a door to take them out at, which must be kept continually shut during the time of working. G H is the fire-place: the fresh fuel is put in at G, and gradually comes down as the fuel below consumes. The part at H is very hot, being filled with the cokes or coals which have ceased to smoke. I is an opening or openings, to admit fresh air, and regulate the fire. K is a door into the space under the boiler; which, being opened, admits air, and stops the draught of the chimney when the operation is wanted to cease. Figure the second is a section of the same fire-place in the other direction; in which M M is the back of the fire-place; L the brick arch on which the fuel lies; and E the ash-hole. Figure 3 is an outside view of the same fire-place, shewing the air-holes I I, and the ash-hole door F; and Figure 4 is a plan of the same, with part of the boiler seating, taken in the line Z Z of Figure 1. The dotted lines represent the flues, and the darts point out the direction of the flame. The fire is first kindled upon the brick arch L, (Fig 1.) and when well lighted, more fuel is gradually added until it is filled up to G; and care is taken to leave proper interstices for the air to pass, either among the fuel, or between the fuel and the front wall N; and as much air is admitted at I I as can be done without causing the smoke to ascend perpendicularly from G, which it will do if too much air is admitted at I I. The dimensions of this fire-place are shewn by the scale, and are properly adjusted for burning about eighty-four pounds weight of coals in an hour; where greater or less quantities are required to be burnt, the furnaces must be enlarged or diminished accordingly; or, if much greater, more furnaces than one must be employed. Figure the fifth represents this new fire-place as applied to a furnace for melting iron and other metals, and construct-

ed without the funnel or perpendicular flue D in Figure 1. N. B. The same letters refer to the same parts in all the preceding figures. I also construct these new fire-places so that the part G H lies sloping, or horizontal, and otherwise vary the figure or form, and proportions, of the same; but, in all cases, the principle is the same; the fresh or raw fuel being placed next the external air, and so that the smoke or flame passes over, or through, the coked or charred part of the fuel. I also occasionally cover the opening G, and cause the air to enter only, or principally, at I I. Secondly, in some cases, I place the fresh fuel on a grate as usual, as at A A, (Figure 6,) and beyond that grate, at or near the place where the flame passes into the flues or chimneys, I place another smaller grate B, on which I maintain a fire of charcoal, cokes, or coals which have been previously burnt until they have ceased to smoke; which, by giving intense heat, and admitting some fresh air, consumes the smoke of the first fire. Lastly, be it remembered, that my said new invention consists only in the method of consuming the smoke, and increasing the heat, by causing the smoke and flame of the fresh fuel to pass through very hot funnels or pipes, or among, through, or near, fuel which is intensely hot, and which has ceased to smoke; and by mixing it with fresh air when in these circumstances; and in the form and nature of the fire-places herein mentioned, described, and delineated: the boilers, and other parts of the furnaces, being such as are in common use. And be it also remembered, that these new-invented fire-places are applicable to furnaces for almost every use or purpose. In witness whereof, &c.

2

Mr W. Thomson's method of consuming smoke 1796.

Fig. 1.

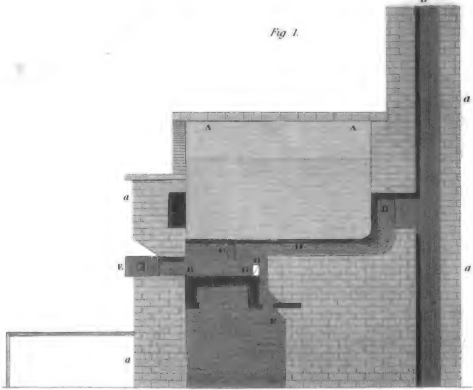
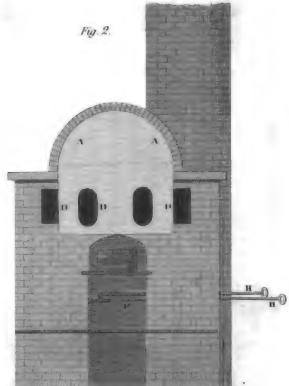


Fig. 2.



Description of a Furnace for Steam-Engines, &c. which effectually consumes the smoke arising from it. In a letter to the editors, from Mr. WILLIAM THOMSON, *of Bow-Lane.* 4 *Rep. Arts,* 1796.

WITH A PLATE.

AS steam-engines are much made use of in this kingdom, and, at the same time, are often found very disagreeable on account of their smoke; I herewith send you a description, and drawing, of a furnace which will effectually consume the smoke arising from it, without requiring more coals than usual, as has been the case with former contrivances for that purpose. It may be adapted to any boiler or copper already set up, and at a very small expence.

Fig. 1, is a section of an oblong boiler, and fire-place.

a a a a. The brick work in which boilers are usually set.

A A. The boiler. Two iron flues run through this boiler, and also go round it.

B B. The fire-place; which must be about one third longer than they are generally made.

C. An arch, which runs across the fire-place, two inches lower than the bottom of the flue under the boiler, and about the middle of the fire-place.

D D D D. Flues through which the hot air ascends, and spends its heat on the boiler.

E. The door of the fire-place; which must have a small shutter in it. Through this shutter the coals must be gently stirred up, by the slice or poker, taking care not to injure the arch, nor to raise too great a quantity of coals at once.

F is a small space left behind the fire, for a current of air to come through, as in the patent lamps.

G. A brick placed with its whole length across the fire-place, to hinder the coals from falling down the space F, and choking it.

Fig. 2, is a front view of the same boiler, and fire-place; in which the same letters represent the same parts.

HH are two slides, the one shifting backwards the other forwards, to make the space F, for the current of air, larger or smaller, as, by practice, may be found best.

Manner in which this Furnace operates.

The arch C hinders the smoke from going up the chimney, and obliges it to pass through the fire behind it; which has a very strong draught, and burns the smoke as it passes through it. The air which comes up through the space F gives fresh vigour to the flame, which consumes any smoke that may be left.

It must be observed that too much air will have a very bad effect, as it will cool the flame: therefore the slides H H must be regulated in such manner as the operator may find most advantageous.

The shutter in the door E must also be of a proper size; as its being too large or too small will be prejudicial.

I am, &c.

W. Thomson.

Method of consuming smoke by James and John Robertson, of Tradestown, near Glasgow, Engineers. Patented August 13, 1800. *Rep. Arts. A. S. No.* 96.

Specification and description of the nature of a new and improved method of constructing furnaces, for the application of fire to steam-engines and boilers of various descriptions, and also the application of fire to many other purposes and branches of manufacture where heat is applied by means of a furnace, by which invention and im-

provement, a very considerable saving of fuel is effected from the immediate conversion of the whole, or very nearly the whole of the smoke arising from the fuel into flame: first, the said invention in principle consists in supplying the burning fuel more fully with air, having this fuel more in a body together, and a less quantity in combustion, at the same time, than what usually takes place in other furnaces, which are applied to the same uses; in applying the fuel with a portion of fresh air, admitted from an opening made for that purpose, and directed in such a manner as it may come in contact with the smoke from the kindling coal and great heat of the furnace together, and the fuel being more fully supplied with air, and consequently a greater degree of heat taking place, and the smoke and fresh air uniting in the great heat, the smoke is inflamed, and rendered useful in adding to the heat of the furnace; besides, this portion of fresh air is so conducted as to act partly on the kindling or kindled fuel, and raising it to a greater degree of heat, after it has served its purpose by uniting with and inflaming the smoke; and therefore is employed, in some measure, usefully, even after the coal has ceased to smoke: secondly, to the above may be added, the form of the furnace, which is so constructed, that the full kindled fuel is kept backward in the furnace, while the fresh coal lies before, and is more gradually kindled than if introduced further among the full kindled fuel, while the heat of the furnace is little injured or damped by the introduction of fresh coal, as is more fully described in the practical description of the furnace. The coal is admitted into the furnace by a hopper, feeder, or mouth-piece, A (Fig. 7 and 8), made of cast iron (but which may be made of other materials), and inclined to the horizon, as in Fig. 7; so that the coal in it, may in some measure, fall into the fire-place, above the bars, as the fuel is spent; in the upper part of this hopper, feeder, or mouth-piece, is a Plate,

a (Fig. 7 and 8), placed at a small distance, or from about three-eighths to three-fourths of an inch from the upper side of the hopper, betwixt which plate, and upper plate, or side of the hopper, a stream of air rushes downward on the fire, at about half a right-angle to the horizon, which stream of air assists in consuming the smoke, as formerly mentioned, and more fully described hereafter. B, Fig. 7, is a section of the bars, which are, in general, a little inclined to the horizon, as in the figure that the fuel may more easily fall, or be pushed backwards, in the furnace; at *c*, is an opening above the bars, and below the lower end of the hopper, which is in general fitted with a grated door or doors, which open for the more convenient cleansing of the furnace, and the grated form of the doors is also designed for admitting air into the fuel, as well as at the bars, consequently the air is more concentrated in the middle of the burning fuel, and produces a greater heat than if admitted only betwixt the bars; this grated form of the doors is also convenient for the admission of a poker or instrument for pushing backward the kindled fuel, while the fresh coal, or that which is not so well kindled, falls down to supply its place; in some others of these furnaces, the opening below the lower end of the hopper, and above the fore end of the bars, is left without doors at all; at this opening, it is convenient, when the fire is mended, to push the coal from the fore side backward, as mentioned above, or it may be pushed backward with a hooked poker, P, by applying the hooked part of it through the furnace bars below; by either of which means the kindled coals are put backwards, while the fresh coal, or that which is not so well kindled, falls down to supply their place; that is, the coals, in the situation *c*, are pushed towards *d*, while those in the situation *f* fall down to supply the place of those which were driven from *c* towards *d*; by such means, the strength or heat of the fire is not much

damped by the introduction of fresh coal, and the coals which have fallen from *f* towards *c*, are not so rapidly kindled as if introduced above the burning fuel: same time the smoke which arises from these newly-introduced coals, passes partly through the full-kindled coal and partly over, and in contact with the great heat of the burning fuel, and, meeting at the same time with the current of fresh air coming downwards, and tending also to drive the smoke still nearer to the bright kindled fuel, does in general completely inflame the smoke, and render it useful in adding to the heat of the furnace. Another end obtained by the stream of fresh air, is to keep in some measure the great heat of the furnace from acting so violently on that part of the hopper which is nearest it, and mostly exposed to its heat, and liable to be damaged thereby, which it does by the continual current of fresh cool air that is in contact with those parts; the construction of the furnace may be much varied; but the chief improvements are, that the fuel in combustion is supplied with air by the foreside as well as by the bars, the hopper is placed in such a situation that the kindled or unkindled coal may in part fall to the foreside of the furnace above the bars, as the other fuel is pushed backward in the furnace, and the admission of fresh air to pass over the burning fuel by means of a definite space or spaces, opening or openings, made for that purpose; so that this stream, current, or currents of air, partly come in contact with the burning fuel itself, forcing also the smoke with more immediate union with the burning fuel and great heat of the furnace. The Patentees do not pretend any claim to the admission of fresh air as a new principle, as they are sensible that this has been known long ago, and practised by admitting it at the furnace door, shutter, or mouth-piece, and at the opening where the coals are admitted into the furnace; their claim rests upon what has been

formerly stated, together with the form of the furnace, and its variations after-mentioned; the success of the furnace depends also upon a considerable degree on what is called the draught of the furnace; that is, the chimney and flues so constructed, as a sufficient current of air may pass through the fire to bring it to a proper degree of heat; also, that the current of fresh air may have such force as to come pretty much in contact with the burning fuel, and to convey the smoke along with it through the hottest of the flame; if this is not the case, the smoke will not be so completely consumed in these furnaces. The hopper is allowed to be kept as full of coal as possible, and either wholly or in part small coal, so as to prevent air as much as possible getting in by that passage; this must be attended to when the furnace is in its ordinary working state; yet, sometimes, it is necessary to keep this opening of the hopper, either wholly, or in part, open, when there is little heat wanted.

Description and reference to the draughts.

Fig. 7, is a side view, or section of the furnace, as if applied to a boiler, and cut through the middle. Fig. 8, is a front view of the furnace in perspective, the hopper having a division in the middle, and two regulating plates for the admission of fresh air. Figs. 7 and 8, A, the hopper into which the coals are put to supply the furnace, *a* the regulating plate; above which and below, the higher plate *b* of the hopper, a stream of fresh air is admitted to this plate; *a* is made to turn on a pin pivot or centre, so that it may be brought nearer to, or recede further from the uppermost at the point *n*, Fig. 7, for regulating the quantity of air admitted betwixt the plate as occasion requires; this plate is sometimes made fast, or kept so, after adopting a space which is judged sufficient for the quantity of fresh air but on other occasions, as in steam engines, it is

Method of consuming Smoke by Jo. J. Roberton of Glasgow. 1800.

Fig 8

Fig 7

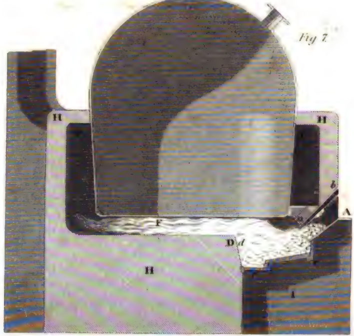
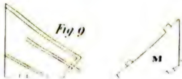


Fig 10

Fig 9



adviseable to give it less or more opening according to the state of the fire, that is, when coals are newly introduced into the fire-place, to give the greatest quantity of fresh air, and when they are pretty well kindled to give less air. F F F, Fig. 7, the flues beneath and round the boiler; that round the boiler, may be in any of the present well-constructed forms; that beneath the boiler, as in the drawing with a breast D, to prevent the coal getting so far backward in the furnace, and also to direct the flame on the bottom of the boiler: this breast is also necessary for the more complete combustion of the smoke, as by that means, the fresh air, smoke, and flame are more completely combined than if the breast were wanting, or ill-formed; at *r* is represented a shutter, which is sometimes used in steam engine boilers for the purpose of getting the refuse of the fuel taken from the furnace by opening the said shutter; in other cases, the breast of the furnace D coincides with *d* at the ends of the bars. G, Figs. 7 and 8, the grated-doors, or opening into the fire-place; I, the ash-pit below the furnace; L, Fig. 8, a catch, or bar, which slides along the bottom plate of the hopper, for keeping the grated-doors shut; H H H, &c. the brick-work for furnace and boiler. K, Fig. 7, a piece of cast-iron in a horizontal position, which joins the under plate of the hopper, for the more ease and convenience in putting in the coals, the hopper may be made in one or more pieces, as inclination or choice may direct, or of any materials which it may be thought prudent to adopt, but they are usually made with five plates of cast-iron; M representing one of the side plates, N the uppermost, O the undermost, and P the regulating-plate; the side plates having tenons which fit into mortices in the top and bottom plate, which may easily be conceived; on the side plates are detents or abutments, which serve as a centre for the regulating-plate to turn upon; on this plate are also two

abutments which rest on the other abutments of the side plates when this plate is put into its place; this plate by such means may be taken out, or put in at any time it is found necessary, without meddling with any other part of the hopper: another method is to have the bottom plate to come out, and in the same manner as the regulating plate; also, that it may fold up or down to any inclination; this form is very commodious for allowing access into the fire-place to get it repaired, or the like, or for having the fire quickly taken from it altogether, for by folding the plate to a level as represented by the dotted line, Fig. 9, the coal which is in the hopper is prevented from falling into the fire-place, and there is a greater space left to get into it; this form may either admit or not of the grated-doors; indeed the simple opening does very well. Fig. 9, is a representation of the side of the hopper, in this form: another method of the hopper, and letting in of air, is by making the underside of the top plate with cheeks, or grooves, as that the fresh air may rush down in them above the fuel that lies in the hopper, for when the hopper is fitted in as close with coal as it can be, these grooves or cheeks prevent the coal from getting into them, and form separate and definite spaces for the air to rush down on the burning fuel, and perform the same office as the regulating plate, though the proper quantity cannot be so well adjusted this way, yet the only way to accomplish this is to have these grooves or cheeks made as near the proper size as possible; they ought also to be so narrow, that little of the coal will get betwixt them. Fig. 10, is a front view of the hopper, in the state where A represents the opening coals are put into; another method is to let in the current of fresh air above the uppermost plate of the hopper, this may be done either by another plate placed above, or the building so formed over it, as that a proper quantity of fresh air may get in, and in a proper direction;

indeed, this may be accomplished many ways in a greater or lesser degree, by letting in a definite quantity, directed in such a manner as to come in contact with the fuel, though perhaps in no way better than the methods explained; to make this furnace more complete, doors are placed to the front, with a sufficient space below them to let air into the furnace, these doors are represented by S S, Fig. 8, as standing open; they are kept shut while the furnace is going, except when coals are put in, or the bars cleansed, or the like when they are opened for that purpose; the use of these doors is to prevent, in a great measure, the radient heat that comes from under the bars and from the opening at the foreside from escaping; this also adds something to the draught or well-going of the furnace, as this heat when suffered to escape rarifies the air before the furnace, which air passes upwards, performing in a small degree that which a chimney does, and depriving the fire of a portion of air which it otherwise has when the doors are shut; these furnaces are made of various sizes, according to the uses they are applied to; in some large ones there is a division in the middle of the hopper, as in Fig. 8; this size, as measured by the scale, will serve a steam-engine boiler of about nine or ten feet diameter; lesser furnaces do not need this division in the middle of the hopper. In witness whereof, &c.

Of Steam and the Steam Engine.

Before I enter directly upon the subject of the steam engine, it will be necessary that the reader should fully comprehend the doctrines of fluidity, evaporation, latent heat and specific heat; and also the facts ascertained respecting the expansive force of steam. The first of the following extracts, which with great brevity and great clearness gives a summary of the doctrine of heat or calo-

ric as connected with fluidity, and vapour or steam, I owe to the 6th edition of Dr. Henry's chemistry, which is not yet commonly known in this country. The second extract, I have taken from Gregory's treatise on mechanics, theoretical, practical, and descriptive, Vol. 2. The tables of Betancourt and Dalton, are from Prony's architecture hydraulique, and the 5th vol. of the Manchester transactions. The account I shall give of the history of the steam engine, I shall adopt from Gregory, Hornblower, and Playfair. Gregory's account in his Encyclopædia, and his plate to that account which I have adopted, are abridged and borrowed from the article steam engine in the Edinburgh Review, and Nicholson and Tilloch's Magazines. And I again request my readers to turn to the excellent articles, "steam," and "steam engine" in that Encyclopædia (Dobson's edit.) as indispensible to be carefully perused, by those who would acquire knowledge on the subject, notwithstanding the illiberal remarks of Gregory and Hornblower on that article and the compiler of it.

Caloric the Cause of Fluidity.

I. *The temperature of melting snow, or of thawing ice, is uniformly the same at all times, and in all places.*—This may be ascertained by the thermometer, which will always, when immersed in liquefying ice or snow, point to 32° of Fahrenheit, whatsoever may be the height of the barometer, or the elevation, above the sea, of the place where the experiment is made. (Shuckburgh, Philosophical Transactions, lxix.)

II. *The sensible heat, or temperature of ice, is not changed by liquefaction.*—A thermometer in pounded ice stands at 32°, and at the very same point in the water which results from the liquefaction of ice.

III. *Yet ice, during liquefaction, must absorb much caloric.*—Expose a pound of water at 32°, and a pound of ice at 32°, in a room, the temperature of which is several degrees above the freezing point, and uniformly the same during the experiment. The water will arrive at the temperature of the room, several hours before the ice is melted; and the melted ice will have, as before its liquefaction, the temperature of 32°. Yet the ice must, during the whole of this time, have been imbibing caloric, because (according to Experiment IV. § 1.) a colder body can never be in contact with a warmer one, without receiving caloric from it. The caloric, therefore, which has entered the ice, but is not to be found in it by the thermometer, is said to have *become latent.* As it is the cause of the liquefaction of the ice, it is sometimes called *caloric of fluidity.*

IV. *The quantity of caloric that enters into a pound of ice, and becomes latent, during liquefaction, may be learned by experiment.*—To a pound of water, at 172°, add a pound of ice at 32°. The temperature will not be the arithmetical mean (102°), but much below it, *viz.* 32°. All the excess of caloric in the hot water has therefore disappeared. From 172° take 32°; the remainder, 140°, shows the quantity of caloric that enters into a pound of ice during liquefaction; that is, as much caloric is absorbed by a pound of ice, during its conversion into water, as would raise a pound of water from 32° to 172°.

It is from the property of its uniformly absorbing the same quantity of caloric for conversion into water, that ice has been ingeniously applied, by Lavoisier and Laplace, to the admeasurement of the heat, evolved in certain operations. Let us suppose the body (from which the caloric, evolved either by simple cooling or combustion, is to be measured) to be inclosed in a hollow sphere of ice,

with an opening at the bottom. When thus placed, the heat, which is given out, will be all employed in melting the ice; and will produce this effect in direct proportion to its quantity. Hence the quantity of ice, which is converted into water, will be an accurate measure of the caloric, that is separated from the body submitted to experiment. In this way, Lavoisier ascertained that equal weights of different combustible bodies melt, by burning, very different weights of ice. The apparatus which he employed for this purpose, he has called the *calorimeter*. Its construction can scarcely be understood without the plate, which accompanies the description in his "Elements of Chemistry."

V. *Other examples of the absorption of caloric, during the liquefaction of bodies*, are furnished by the mixture of snow and nitric acid, or of snow and common salt, both of which, in common language, produce intense cold.*

1. Dilute a portion of nitric acid with an equal weight of water; and, when the mixture has cooled, add to it a quantity of light fresh-fallen snow. On immersing the thermometer in the mixture, a very considerable reduction of temperature will be observed. This is owing to the absorption, and intimate fixation, of the free caloric of the mixture, by the liquefying snow.

2. Mix quickly together equal weights of fresh-fallen snow at 32°, and of common salt cooled, by exposure to a freezing atmosphere, down to 32°. The two solid bodies, on admixture, will rapidly liquefy; and the thermometer will sink 32°, or to 0; or, according to Sir C. Blagden, to 4° lower. (Philosophical Transactions, lxxviii. 281.) To understand this experiment, it must be recollected, that the snow and salt, though at the freezing tem-

* The extraordinary powers of muriate of lime and snow, in generating cold, will be described hereafter.

perature of water, have each a considerable portion of uncombined caloric. Now, salt has a strong affinity for water; but the union cannot take place while the water continues solid. In order, therefore, to act on the salt, the snow absorbs all the free caloric required for its liquefaction; and during this change, the free caloric, both of the snow and of the salt, amounting to 32°, becomes latent, and is concealed in the solution. This solution remains in a liquid state at 0, or 4° below 0 of Fahrenheit; but if a greater degree of cold be applied to it, the salt separates in a concrete form.

3. Most neutral salts, also, during solution in water, absorb much caloric; and the cold, thus generated, is so intense as to freeze water, and even to congeal mercury. The former experiment, however (*viz.* the congelation of water), may easily be repeated on a summer's day. Add to 32 drachms of water, 11 drachms of muriate of ammonia, 10 of nitrate of potash, and 16 of sulphate of soda, all finely powdered. The salts may be dissolved separately, in the order set down. A thermometer, put into the solution, will show, that the cold produced is at or below freezing; and a little water, in a thin glass tube, being immersed in the solution, will be frozen in a few minutes. Various other freezing mixtures are described in Mr. Walker's papers in the Philosophical Transactions for 1787, 88, 89, 95, and 1801. Of these the table, given in the Appendix, for which I am indebted to the obliging communication of the author, contains an arranged abstract.

4. Muriate of lime, when mixed with snow, produces a most intense degree of cold. This property was discovered some years ago by M. Lowitz, of St. Petersburg, and has been since applied, in this country, to the congelation of mercury on a very extensive scale. The proportions which answer best, are about equal weights of

the salt finely powdered, and of fresh-fallen and light snow. On mixing these together, and immersing a thermometer in the mixture, the mercury sinks with great rapidity. For measuring exactly the cold produced, a spirit-thermometer, graduated to 50° below 0 of Fahrenheit, or still lower, should be employed. A few pounds of the salt are sufficient to congeal a large mass of mercury. By means of 13 pounds of the muriate, and an equal weight of snow, Messrs. Pepys and Allen froze 56 pounds of quicksilver into a solid mass. The mixture of the whole quantity of salt and snow, however, was not made at once, but part was expended in cooling the materials themselves.

On a small scale it may be sufficient to employ two or three pounds of the salt. Let a few ounces of mercury, in a very thin glass retort, be immersed first in a mixture of one pound of each; and when this has ceased to act, let another similar mixture be prepared. The second will never fail to congeal the quicksilver.

The salt thus expended may be again evaporated, and crystallized for future experiments.

The reader, who wishes for farther particulars respecting these experiments, is referred to the Philosophical Magazine, vol. iii. p. 76.

VI. *On the contrary, liquids, in becoming solid, evolve or give out caloric, or, in common language, produce heat.*

1. Water, if kept perfectly free from agitation, may be cooled down several degrees below 32°; but, on shaking it, it immediately congeals, and the temperature rises to 32°.

2. Expose to the atmosphere, when at a temperature below freezing (for example, at 25° of Fahrenheit), two equal quantities of water, in one only of which about a fourth of its weight of common salt has been dissolved. The saline solution will be gradually cooled, without freezing, to 25°. The pure water will gradually descend

to 32°, and will there remain stationary a considerable time before it congeals. Yet while thus stationary, it cannot be doubted, that the pure water is yielding caloric to the atmosphere, equally with the saline solution; for it is impossible that a warmer body can be surrounded by a cooler one, without imparting caloric to the latter. The reason of this equable temperature is well explained by Dr. Crawford. (*On Heat*, p. 80.) Water, he observes, during freezing, is acted upon by two opposite powers: it is deprived of caloric by exposure to a medium, whose temperature is below 32°; and it is supplied with caloric, by the evolution of that principle from itself, *viz.* of that portion which constituted its fluidity. As these powers are exactly equal, the temperature of the water must remain unchanged, till the caloric of fluidity is all evolved.

3. The evolution of caloric, during the congelation of water, is well illustrated by the following experiment of Dr. Crawford:—Into a round tin vessel put a pound of powdered ice; surround this by a mixture of snow and salt in a larger vessel; and stir the ice in the inner one, till its temperature is reduced to + 4° of Fahrenheit. To the ice thus cooled, add a pound of water at 32°. One 5th of this will be frozen; and the temperature of the ice will rise from 4° to 32°. In this instance, the caloric, evolved by the congelation of one 5th of a pound of water, raises the temperature of a pound of ice 28°.

4. If we dissolve sulphate of soda in water, in the proportion of one part to five, and surround the solution by a freezing mixture, it cools gradually down to 31°. The salt, at this point, begins to be deposited, and stops the cooling entirely. This evolution of caloric, during the separation of a salt, is exactly the reverse of what happens during its solution. (Blagden, Philosophical Transactions, lxxviii. 290.)

5. To a saturated solution of sulphate of potash in water, or of any salt that is insoluble in alcohol, add an equal measure of alcohol. The alcohol, attracting the water more strongly than the salt retains it, precipitates the salt, and considerable heat is produced.

Caloric the Cause of Vapour.

I. *Every liquid, when of the same degree of chemical purity, and under equal circumstances of atmospheric pressure, has one peculiar point of temperature, at which it invariably boils.*—Thus, pure water always boils at 212°, alcohol at 176, and ether at 98° Fahrenheit; and, when once brought to the boiling point, no liquid can be made hotter, however long the application of heat be continued. The boiling point of water may be readily ascertained, by immersing a thermometer in water boiling over the fire. As there is some danger in applying heat directly to a vessel containing either ether or alcohol, the ebullition of these fluids may be shown, by immersing the vessel containing them in water, the temperature of which may be gradually raised. The appearance of boiling is owing to the formation of vapour at the bottom of the vessel, and its escape through the heated fluid above it. That the steam, which escapes, is actually formed at the bottom, and not at the top of the water, may be seen by boiling some water in a Florence flask, or other transparent vessel, over an Argand's lamp. The bubbles of vapour will all ascend from the bottom of the vessel.

II. *Steam has exactly the same temperature as boiling water.*—Let a tin vessel be provided, having two holes in its cover, one of which is just large enough to admit the stem of a thermometer. Fill it partly with water, and let the bulb of the thermometer be an inch or two above the surface of the water, leaving the other aperture open

for the escape of vapour. When the water boils, the thermometer, surrounded by steam, will rise to 212°, which is precisely the temperature of the water beneath; yet water, placed on a fire, continues to receive heat, very abundantly, even when boiling hot; and as this heat is not appreciable by the thermometer, it must exist in the steam, in a latent state.

Perfectly formed steam is entirely invisible. We may satisfy ourselves of this by boiling strongly a small quantity of water in a flask; for complete transparency will exist in the upper part of the vessel. It is only when it begins to be condensed, that steam becomes visible. We have a proof also, of the same fact in the thick fogs, which are produced by a sudden transition from warm to cold weather; the vapour, which was imperceptible at the higher temperature, being condensed and rendered visible by the lower.

III. *The boiling point of the same fluid varies, under different degrees of atmospheric pressure.* Thus, water, which has been removed from the fire, and ceased to boil, has its ebullition renewed, when it is placed under a receiver, the air of which is quickly exhausted by an air pump. Alcohol and ether, confined under an exhausted receiver, boil violently at the temperature of the atmosphere. In general, liquids boil *in vacuo*, with about 140° less of heat, than are required under a mean pressure of the atmosphere. (Black's Lectures, i. 151.) Even the ordinary variations in the weight of the air, as measured by the barometer, are sufficient to make a difference in the boiling point of water of about 5° between the two extremes.* On ascending considerable heights, as to the tops of mountains, the boiling point of water gradually

* Sir G. Shuckburgh, in Philosophical Transactions, lxxix. 375.

falls on the scale of the thermometer. Thus on the summit of Mount Blanc, water was found by Saussure to boil at 187° Fahrenheit.*

The influence of a diminished pressure in facilitating ebullition, may be inferred also from the following very simple experiment: Place, over a lamp, a Florence flask, about three 4ths filled with water; let it boil briskly during a few minutes; and, immediately on removing it from the lamp, cork it tightly, and suddenly invert it. The water will now cease to boil; but, on cooling the convex part of the flask by a stream of cold water, the boiling will be renewed. Applying boiling water from the spout of a tea-kettle to the same part of the flask, the water will again cease to boil. This renewal of the ebullition, by the application of cold (an apparent paradox,) is owing to the formation of an imperfect vacuum over the hot water, by the condensation of steam; and the suspension of the boiling, on re-applying the heat, to the renewed pressure on the surface of the hot water, occasioned by the formation of fresh steam.

From these facts, it may be inferred, that the particles of caloric are mutually repulsive, and that they communicate this repulsive tendency to other bodies in which caloric is contained. This repulsive power tends to change solids into fluids, and liquids into aëriform bodies, and is chiefly counteracted by the pressure of the atmosphere.

Were this counteracting cause removed, many bodies, which at present have a liquid form, would cease to be such, and would be changed into a gaseous state. Precisely the same effect, therefore, results from the prevalence of either of these forces. Add to certain liquids a quantity of caloric, in other words, place them in a high

* This furnishes one of the means of measuring the height of mountains.

temperature, and they are immediately converted into gases; or, their temperature remaining the same, diminish the weight of the atmosphere; and the caloric, which they naturally contain, exerts its repulsive tendency with equal effect, and they are in like manner converted into gases. These facts are best shown by the following experiments on ether:

1. Ether, at the temperature of 104°, exists in the state of a gas. This may be shown by filling a jar with water of this temperature, and inverting it in a vessel of the same. Then introduce a little ether, by means of a small glass tube closed at one end. The ether will rise to the top of the jar, and, in its ascent, will be changed into gas, filling the whole jar with a transparent invisible elastic fluid. On permitting the water to cool, the ethereal gas is condensed, and the inverted jar again becomes filled with water.

2. Ether is changed into gas by diminishing the weight of the atmosphere. Into a glass tube, about six inches long, and half an inch in diameter, put a tea-spoonful of ether, and fill up the tube with water; then, pressing the thumb on the open end of the tube, place it, inverted, in a jar of water. Let the whole be set under the receiver of an air pump, and the air exhausted. The ether will be changed into gas, which will expel the water entirely from the tube. On re-admitting the air into the receiver, the gas is again condensed into a liquid form.

IV. *On the contrary, by considerably increasing the pressure, water may be heated to above 400° Fahrenheit, without being changed into vapour.* This experiment requires, for its performance, a strong iron vessel, called a Papin's digestor, *" which is an iron boiler holding half

* The lines marked with brackets, I have substituted for Dr. Henry's text, which refers to figures that I cannot give. T. C.

" a gallon or a gallon; with a cover that screws on so " accurately as to be steam-tight. In the cover is a hole, " which may be stopped with a stopper of any kind, as " of cork or soft wood. This stopper is attached to a " lever, of which one end is fastened by a joint or hinge " to the middle of the cover, and on the other end which " projects beyond the cover, weights may be hung as on " the end of a steel-yard. The stopper is kept down by " a pressure, which is measured by the weight suspended " at the end of the lever. In this vessel, steam may be " made nearly red-hot. A thermometer graduated to " 400 degrees, or upwards, may be fixed in the cover, " and secured; but it is not prudent to give a heat beyond " 300 or 350.

" When the barometer is about half way between 29 " and 30, the heat of boiling water is indicated by 212 of " Fahrenheit's thermometer. When the safety valve is " loaded with one atmosphere, or 14lbs. the water will " rise to 240. When, with two atmospheres or 28lbs. it " will raise the mercury to 270 degrees.

" The barometer being as above mentioned, that is, " about the average weight of the atmosphere, the boiling " point of ether is 98° of Fahrenheit: of alcohol of specific " gravity ,825, 176°; water, 212°; oil of turpentine, " 560°; linseed oil, 600°; mercury, 660°.

" According to the experiments of Professor Robison, " a vacuum occasions liquids of whatever kind, to boil " at 145 degrees lower, than they would boil under an at- " mospheric pressure indicated by 30 inches of the baro- " meter. At this rate, water ought to boil in vacuo at 67° " Fahrenheit; but Dr. Thompson found the boiling point " of water under the best vacuum he could make, of " course not a perfect one, 90 degrees.

" It may be useful to state, that according to Achard's " experiments, water saturated with common salt is enab-

" led to receive an addition of heat equal to 10,35°, that " is, water saturated with common salt boils at 222,35, " when it would otherwise boil at 212. If saturated with " sal ammoniac, it boils at 221,79. Borax, sulphat of " magnesia, and sulphat of lime, lowered the boiling point. " These are facts important to the theory of a steam en- " gine."

V. *The absorption of caloric, during evaporation, shown by experiment.*—Moisten a thermometer with alcohol, or with ether, and expose it to the air, repeating these operations alternately. The mercury of the thermometer will sink at each exposure, because the volatile liquor, during evaporation, robs it of its heat. In this way (especially with the aid of an apparatus described by Mr. Cavallo, in the Philosophical transactions, 1781, p. 509), water may be frozen in a thin and small glass ball, by means of ether. The same effect may be obtained, also, by immersing a tube, containing water at the bottom, in a glass of ether, which is to be placed under the receiver of an air pump; or the ether may be allowed to float on the surface of the water. During the exhaustion of the vessel, the ether will evaporate rapidly; and, robbing the water of heat, will completely freeze it; thus exhibiting the singular spectacle of two fluids in contact with each other, one of which is in the act of boiling, and the other of freezing, at the same moment.

VI. *The fixation of caloric in water, by its conversion into steam, may be shewn by the following experiments:* —1. Let a pound of water at 212°, and eight pounds of iron filings at 300°, be suddenly mixed together. A large quantity of vapour will be instantly generated; and the temperature of the mixture will be only 212°; but that of the vapour produced, is also not more than 212°; and the steam must therefore contain, in a latent or combined

form, all the caloric which raised the temperature of eight pounds of iron filings from 212° to 300°.

2. The quantity of caloric, which thus becomes latent during the formation of steam, may be approximated, by repeating the following experiment of Dr. Black: He placed two cylindrical flat bottomed vessels of tin, five inches in diameter, and containing a small quantity of water at 50°, on a red hot iron plate, of the kind used in kitchens. In four minutes the water began to boil, and in twenty minutes the whole was boiled away. In four minutes, therefore, the water received 162° of temperature, or 40½° in each minute. If we suppose, therefore, that the heat continues to enter the water at the same rate, during the whole ebullition, we must conclude that $40\frac{1}{2}° \times 20° = 810°$ have entered the water, and are contained in the vapour.

It has been found by experiment that 75 pounds of Newcastle coal, or 100 pounds of coal of medium quality, applied in the best manner, are required for the vaporization of 12 cubic feet, or about 89¾ wine gallons of water. A pound of coal, on the average, may be considered as equivalent to convert a gallon of water into vapour.*

VII. *Water, by conversion into steam, has its bulk prodigiously enlarged; viz. according to Mr. Watt's experiments, about* 1800 *times.* A cubic inch of water (or 252 grains) occupies, therefore, when converted into steam, the space of rather more than a cubic foot. Hence its specific gravity, under the ordinary pressure of the air, is to that of common air, nearly as 450 to 1000, or 9 to 20.

* The consumption of coal in Boulton and Watt's steam engine, is about 5½lb. per hour for the power of one horse: that is a power equal to the raising 33000lb. one foot high in a minute.

T. C.

VIII. *On the contrary, vapours, during their conversion into a liquid form, evolve, or give out, much caloric.* The heat given out, by the condensation of steam, is rendered apparent by the following experiment: Mix 100 gallons of water at 50°, with 1 gallon of water at 212°. The temperature of the water will be raised about 1½°. Condense by a common still-tub, 1 gallon of water, from the state of steam, by 100 gallons of water, at the temperature of 50°. The water will be raised 11°. Hence, 1 gallon of water, condensed from steam, raises the temperature of 100 gallons of cold water 9½° more than 1 gallon of boiling water; and, by an easy calculation, it appears, that the caloric imparted to the 100 gallons of cold water by 8 pounds of steam, if it could be condensed in 1 gallon of water, would raise it to 950°. (Black's Lectures, i. 169.)

For exhibiting the same fact, by means of a small apparatus, which may be placed on a table, and with the assitance only of a lamp, the boiler already described (fig.* 46) will be found extremely well adapted. The right angle pipe *e* must be screwed, however, into its place, and must be made to terminate at the bottom of a jar, containing a known quantity of water of a given temperature. This conducting pipe and the jar should be wrapped round with a few folds of flannel. The apparatus being thus disposed, let the water in the boiler be heated by an Argand's lamp, with double concentric wicks, till steam issues in considerable quantity through the cock *c*, which is then to be closed. The steam will now pass through the right angled pipe into the water contained in the jar, which will condense the steam, and will have its temperature very considerably raised. Ascertain the augmentation of temperature and weight; and the result will show, how much a given weight of water has had its tempera-

* I cannot give the figure here. T. C.

ture raised by a certain weight of condensed steam. To another quantity of water, equal, in weight and temperature to that contained in the jar at the outset of the experiment, add a quantity of water at 212°, equal in weight to the condensed steam; it will be found, on comparison of the two resulting temperatures, that a given weight of steam has produced, by its condensation, a much greater elevation of temperature, than the same quantity of boiling water. This will be better understood by the following example, taken from actual experiment:

Into eight ounces of water, at 50° Fahrenheit, contained in a glass jar, steam was passed from a boiler, till the temperature of the water in the jar rose to 173°. On weighing the water, it was found to have gained 8½ drachms; that is, precisely 8½ drachms of steam had been condensed, and had imparted its heat to the water.* To facilitate the explanation of this experiment, it is necessary to premise the following remarks.

To measure the whole quantities of caloric contained in different bodies, is a problem in chemistry which has not yet been solved. But the quantities of caloric, added to, or substracted from, different bodies (setting out from a given temperature) may, in many cases, be measured and compared with considerable accuracy. Thus, if, as has been already stated, two pounds of water at 120° be mixed with two pounds at 60°, half the excess of caloric in the hot water will pass to the colder portion; that is, the hot water will be cooled 30°, and the cold will re-

* I find the following a convenient method of performing this experiment. In a tin vessel holding a quart, inclosed in another tin vessel and surrounded by an inch of powdered and well dried charcoal, put one pint or 16 oz. by weight of water at the common temperature of the room. Into a small retort put one ounce of water of the same temperature. Evaporate it by a patent lamp, placing the end of the retort in the pint of water. When evaporated try the temperature of the water in the tin vessel. T. C.

ceive 30° of temperature; and if the experiment be conducted with proper precautions, 90°, the arithmetical mean of the temperature of the separate parts, will be the temperature of the mixture. If three pounds of water at 100° be mixed with one pound at 60°, we shall have the same quantity of heat as before, *viz.* four pounds at 90°. Hence, if the quantity of water be multiplied by the temperature, the product will be a comparative measure of the quantity of caloric which the water contains, exceeding the zero of the thermometer employed.

Thus, in the last example,

3 × 100 = 300 = the caloric above zero in the first portion.
1 × 60 = 60 = the caloric above zero in the second do.

The sum, 360 = the caloric above zero in the mixture.

Dividing 360 by 4, the whole quantity of water, we obtain 90°, the temperature of the mixture.

This method of computation may be conveniently applied to a variety of cases. Thus, in the foregoing experiment, 8½ drachms of steam at 212°, added to 64 drachms of water at 50°, produced 72½ drachms of water at 173°. Now,

72½ × 173 = 12542½ = whole heat of the mixture.
64 × 50 = 3200 = heat of 64 drachms, one of the component parts.

9342½ = heat of 8½ drachms, the other component part.

Therefore 9342½ divided by 8½ = 1099, should have been the temperature of the latter portion (*viz.* 8½ drachms), had none of its heat been latent: and 1099 —212 = 887 gives the latent heat of the steam. This result does not differ more than might be expected, owing to the unavoidable inaccuracies of the experiment, from Mr. Watt's determination, which states the latent heat of steam at 900°, or from that to 950°. (Black's Lectures, i. 174.) La-

voisier, with the aid of the calorimeter, makes it 1000° or a little more. (Ibid. 175.)

IX. *The same weight of steam contains, whatever may be its density, the same quantity of caloric; its latent heat being increased in exact proportion as its sensible heat is diminished; and the reverse.*—This principle, though scarcely admitting of illustration by any easy experiment, is one of considerable importance; and an ignorance of it has been the occasion of many fruitless attempts to improve the economy of fuel in the steam engine. The fact, so far as respects steam of lower density than that of 30 inches of mercury, was long ago determined experimentally by Mr. Watt. (Black, i. 190.) As the boiling point of liquids is known to be considerably reduced under a diminished pressure, it seemed reasonable to suspect that, under these circumstances, steam might be obtained from them with a less expenditure of heat. Water, Mr. Watt found, might easily be distilled in vacuo when in the temperature of only 70° Fahrenheit. But, by condensing steam formed at this temperature, and observing the quantity of heat which it communicated to a given weight of water, he determined that its latent heat, instead of being only 950°, was between 1200° and 1300°.

The same principle may be explained, also, by the following illustration, which was suggested to me by Mr, Ewart. Let us suppose that in a cylinder, furnished with a piston, we have a certain quantity of steam, and that it is suddenly compressed, by a stroke of the piston, into half its bulk. None of the steam will in this case be condensed; but it will acquire double elasticity, and its temperature will be considerably increased. Now if we either suppose the cylinder incapable of transmitting heat, or take the moment instantly following the compression before any heat has had time to escape, it must be evident that the sensible and latent heat of the steam, taken toge-

ther before compression, are precisely equal to the sensible and latent heat taken together of the denser steam. But in the dense steam, the sensible heat is increased, and the latent heat proportionally diminished. The explanation of this fact will be furnished by a principle to be hereafter explained, *that the capacities of elastic fluids for caloric are uniformly diminished by increasing their density.*

The large quantity of caloric, latent in steam, renders its application extremely useful for practical purposes. Thus, water may be heated, as in the foregoing experiment, at a considerable distance from the source of heat, by lengthening the conducting pipe *e*. This furnishes us with a commodious method of warming the water of baths, which, in certain cases of disease, it is of importance to have near the patient's bed room; for the boiler, in which the water is heated, may thus be placed on the ground floor, or in the cellar of a house; and the steam conveyed by pipes into an upper apartment. Steam may also be applied to the purpose of heating or evaporating water, by a modification of the apparatus.

Specific Caloric.

Equal weights of the *same* body, at the same temperature, contain the same quantities of caloric. But equal weights of *different* bodies, at the same temperature, contain unequal quantities of caloric. The quantity of caloric, which one body contains, compared with that contained in another, is called its *specific caloric;* and the power or property, which enables bodies to retain different quantities of caloric, has been called *capacity for caloric*. The method of determining the specific caloric, or comparative quantities of caloric in different bodies, is as follows:

It has already been observed, that equal weights of the *same* body, at different temperatures, give, on admixture, the arithmetical mean. Thus, the temperature of a pint

of hot water and a pint of cold, is, after mixture, very nearly half way between that of the two extremes. But this is not the case, when equal quantities of *different* bodies, at different temperatures, are employed.

(*a*) If a pint of quicksilver at 100° Fahrenheit, be mixed with a pint of water at 40°, the resulting temperature will not be 70° (the arithmetical mean), but only 60°. Hence the quicksilver loses 40° of heat, which nevertheless raise the temperature of the water only 20°; in other words, a larger quantity of caloric is required to raise the temperature of a pint of water, than that of a pint of mercury, through the same number of degrees. Hence it is inferred, that water has a greater capacity for caloric than is inherent in quicksilver.

(*b*) The experiment may be reversed, by heating the water to a greater degree than the quicksilver. If the water be at 100°, and the mercuryat 40°, the resulting temperature will be nearly 80°; because the pint of hot water contains more caloric, than is necessary to raise the quicksilver to the arithmetical mean.

(*c*) Lastly if we take two measures of quicksilver to one of water, it is of no consequence which is the hotter; for the resulting temperature is always the mean between the two extremes; for example, 70°, if the extremes be 100° and 40°. Here, it is manifest, that the same quantity of caloric, which makes one measure of water warmer by 30°, is sufficient for making two measures of quicksilver warmer by the same number. Quicksilver has, therefore, a less capacity than water for caloric, in the proportion, when equal measures are taken, of one to two.

If, instead of equal *bulks* of quicksilver and water, we had taken equal *weights*, the disparity between the specific caloric of the mercury and water would have been still greater. Thus a pound of water at 100°, mixed with a pound of mercury at 40°, gives a temperature of 97½,

or $27\frac{1}{2}°$ above the arithmetical mean. In this experiment, the water, being cooled from 100° to $97\frac{1}{2}°$ has lost a quantity of caloric reducing its temperature only $2\frac{1}{2}°$; but this caloric, communicated to the pound of mercury, has produced, in its temperature, a rise of no less than $57\frac{1}{2}°$. Therefore, a quantity of caloric, necessary to raise the temperature of a pound of water $2\frac{1}{2}°$, is sufficient to raise that of a pound of mercury $57\frac{1}{2}°$; or, by the rule of proportion, the caloric, which raises the temperature of a pound of water 1°, will raise that of a pound of quicksilver about 23°. Hence it is inferred, that the quantity of caloric contained in water, is to that contained in the same *weight* of quicksilver as 23° to 1°. Or, stating the caloric of water at 1°, that of quicksilver will be $\frac{1}{23}$ part of 1°, or 0,435*.

When this comparison is extended to a great variety of bodies, they will be found to differ very considerably in their capacities for caloric. The results of numerous experiments of this kind are comprised in a table of specific caloric.

The capacities of bodies for caloric, influence considerably, the rate at which they are heated and cooled. In general, those bodies are most slowly heated, and cool most slowly, which have the greatest capacities for heat.† Thus, if water and quicksilver be set, in similar quantities, and at equal distances before the fire, the quicksilver will be much more rapidly heated than the water; and, on removal from the fire, it will cool with proportionally greater quickness than the water. By ascertaining the comparative rates of cooling, we may even determine, with tolerable exactness, the specific caloric of bodies;

* The above numbers, which differ from those commonly stated, are given on the authority of Mr. Dalton.

† See Martine, on Heat, page 74.

and particularly of one class (the gases), which are not easily compared in any other way. (See Leslie on Heat, chap. xxi.)

ON THE ELASTICITY OF STEAM.*

2 Gregory's System of Mechanics.

Since the important invention of the Steam-engine, another species of first movers has come under the consideration of the mechanical investigator, namely, such as arise from the volatilisation of different fluids. Of these the one most commonly chosen is the STEAM raised from hot water, which is an elastic fluid, and which when raised with the ordinary heat of boiling water, is almost 3000 times rarer than water, or more than $3\frac{1}{2}$ times rarer than air, and then has its elasticity equal to that of the common atmospheric air: by great heat it has been found that the steam may be expanded into 14000 times the space of water, and then exerts a force of nearly 5 times the pressure of the atmosphere: and there is no reason to suppose this is the limit: indeed some accidents which have happened, prove clearly, that the elastic force of steam may at least equal that of gunpowder.

The observations on the different degrees of temperature acquired by water in boiling, under different pressures of the atmosphere, and the formation of the vapour from water under the receiver of an air-pump, when with the common temperatures the pressure is diminished to a certain degree, shew clearly that the expansive force of vapour or steam is different in the different temperatures, and that in general it increases in a variable ratio as the temperature is raised. Previous to describing the method which has been adopted to measure the force of steam

* Abridged from Prony's Architecture hydraulique: Prony's account of Betancourt's experiments, Journal de l'Ecole polytechnique: 1 Phil. Mag. 345. T. C.

under different temperatures, it will be proper to describe briefly the method by which the Chemists account for the production of aeriform fluids.

The term *Caloric* is used to denote the cause, whatever it may be, of heat, and of the phenomena which accompany heat: it is now almost universally admitted to be a highly elastic fluid. Every body is according to its nature, capable of containing under a given volume a certain quantity of caloric, either greater or less: this property was first observed by Dr. Black, and the English chemists designated it by the term *Capacity of a body to contain the matter of heat.* Professor Wilcke and M. Lavoisier first made use of the term *specific caloric*, denoting by it the quantity of caloric respectively necessary to elevate to the same number of degrees the temperature of several bodies of equal weight.

Substances volatilised and reduced to *gas* or aeriform fluids, are nothing else than ordinary solid or fluid bodies which by some circumstance are found superabundantly combined with caloric; in such a manner that the constituent particles of these bodies are separated the one from the other, by a quantity of ambient caloric much more considerable than that which surrounds the same particles in the natural state of the bodies. The extreme elasticity of the caloric the effect of which is augmented by its condensation, and the weakening of the reciprocal attraction or of the cohesion of the particles of the bodies (a weakening or diminution produced by the increased distance of those particles) concur to diminish the density of the bodies in such a manner that they become reduced to an aeriform state.

As to the elasticity of gaseous fluids thus formed, it appears in great measure to be produced by the elasticity of caloric itself, which, when bodies are reduced to the gaseous state; occupy a very great part of their volume.

This eminent elasticity of caloric tends continually to produce expansion; on the other hand, this fluid, by a particular destination of nature, is more or less disseminated between the moleculæ of all bodies, in such sort that we may say with M. Lavoisier that even in the solid state these moleculæ do not touch, but, as it were, *swim* in the caloric at a certain distance from each other. There must, therefore, be a perpetual contest between the expansive force of caloric which tends to disseminate the moleculæ, and the cohesive attraction of the moleculæ which tends to join them together. From the reciprocal inintensity of these two powers results the solid and liquid states of bodies: thus, water only differs from ice by the greater or less condensation of caloric, which permits more or less of the moleculæ of the liquid to yield to the effect of their attraction or reciprocal cohesion.

When substances pass from the liquid to the aeriform state, there is a third power to combine with the expansive effort of caloric, and the aggregative or attractive effort of the moleculæ; namely, the pressure of the atmosphere, or of any elastic fluid whatever which compresses the fluid, and opposes itself to the separation of its parts. This third power has a certain influence also upon the passage from the solid to the fluid state, but it is most frequently (in this case) very small, and even evanescent in comparison of the resistance arising from the mutual cohesion of the moleculæ. The contrary effect has place in the course of the passage from the liquid to the gaseous or aeriform state; the cohesion of the fluid moleculæ being extremely small, the elasticity of the caloric has scarcely any thing to surmount to produce volatilisation besides the pressure of the atmosphere, or gas which actually compresses it.

Hence it results that the same liquid under different pressures ought to volatilise at different temperatures. M. Lavoisier proved the truth of this result, by placing ether

under the receiver of an air-pump and producing volatilisation solely by taking off a part of the pressure of the atmosphere. See *Chymie, tome I. pa.* 9. And we know by many expriments of M. De Luc and others, that water boils the more speedily as it is less pressed by the weight of the atmosphere.

Lavoisier notices a curious consequence of what has been here said; which is, that if our planet revolved upon its axis, with such a velocity as to lessen the pressure of the atmosphere, or if the temperature of the air were raised, then several fluids which we now see under a liquid state would only exist in the aeriform state; for example, if under the temperature of summer the pressure of the atmosphere were only equivalent to 20 or 24 inches of the barometrical tube, that pressure would not retain Ether in the fluid state, it would be changed into gas; and the like would happen, if while the pressure of the air was equivalent to 28 or 30 inches of the mercury the habitual temperature were 105 or 110 degrees on Fahrenheit's scale.

The principles which have been here exhibited are sufficient for the undestanding of all which relates to the action of water or other fluids reduced to vapour. Now, it has appeared from frequent experiments that water heated in common air volatilises at 80° of Reaumur's thermometer, or 212° of Fahrenheit's, the height of the barometer being 28 French, or 29·9 English inches: and spirits of wine under a like pressure volatilises at between 63° and 64° of Reaumur, or nearly 175° of Fahrenheit. The expansive force of the vapour must, therefore, in both these cases, according to the principles just explained, be measured by a column of mercury of 28 French, or 29·9 English inches, in like manner as such a column measures the pressure of the atmosphere, or the ealasticity of common air. And at any more elevated temperatures the elastic force of the vapour will surpass the pressure of the

atmosphere by a quantity which has a certain relation with the excess of the temperature above those just stated.

Till lately there was wanting on this important subject series of exact and direct experiments by means of which, having given the temperature of the heated fluid, the expansive force of the steam rising from it might be known, and *vice versa*. There was likewise wanting an analytical theorem expressing the relation between the temperature of the heated fluid and the pressure with which the force of the steam was in equilibrio. These desiderata have, however, been lately supplied by M. Bettancourt, an ingenious Spanish philosopher, after a method which we shall now concisely explain.*

M. Bettancourt's apparatus consists of a copper vessel or boiler, with its cover firmly soldered on: this cover has three orifices which close up with screws: at the first the water or other fluid is put in and out; through the second passes the stem of a thermometer which has the whole of its scale or graduations above the vessel, and its ball within, where it is immersed either in the fluid or in the steam according to the different circumstances; through the third hole passes a tube, making a communication between the cavity of the boiler and one branch of an inverted syphon, which contains mercury, and acts as a barometer for measuring the pressure of the elastic vapour within the boiler. In the side of the vessel there is a fourth hole into which is inserted a tube with a turn-cock, making a communication with the receiver of an air-pump, in order to extract the air from the boiler and to prevent its return.

The apparatus being prepared in good order, and distilled water introduced into the boiler at the first hole, and then stopped, as well as the end of the inverted syphon or barometer, M. Bettancourt surrounded the boiler with ice,

* See 1 Phil. Mag. 345. T. C.

to lower the temperature of the water to the freezing point, and then, having extracted all the air from the boiler by means of the air-pump, the difference between the columns of mercury in the two branches of the barometer shewed the measure of the elastic force of the vapour arising from the water in that temperature. Then lighting the fire below the boiler, he gradually raised the temperature of the water from 0 to 110° of Reaumur's thermometer, that is, from 32° to 279½° of Fahrenheit's thermometer; and for each degree of elevation in the temperature he observed the height of the mercurial column which measured the elasticity or pressure of the vapour.

These experiments were repeated various times and with different quantities of water in the vessel; their results were arranged in different columns for the sake of comparison, and it appeared that the pressures for different temperatures agreed very nearly, however much the quantity of fluid in the vessel was varied. It was also seen that the increase in the expansive force of the vapour is at first very slow; but increases gradually unto the higher temperatures, where the increase becomes very rapid, as will be obvious from an examination of the tables in some of the following pages.

To express the relation between the degrees of temperature of the vapour and its elastic force, this philosopher employs a method suggested by M. Prony, which consists in imagining the heights of the columns of mercury measuring the expansive force to represent the ordinates of a curve, and the degrees of heat the corresponding abscissæ of that curve; making the ordinates equal to the sum of several logarithmic ones which contain two indeterminates, and ascertaining these quantities in such manner that the curve may agree with a tolerable number of observations taken throughout the whole extent of the change of temperature, from the lowest to the highest extreme of the experiments. Then a formula or equation

to a curve is investigated, and when the curve corresponding to that equation is constructed, if it coincide (with the exception of a few trifling anomalies) with the curve constructed by the results of the experiments, the formula may be looked upon as correct, and furnishing a true analytical representation of the phenomena. This was done by M. Bettancourt, and the curve constructed from this equation has a point of inflexion at about the 102° of Reaumur,* as it ought to have, because the second differences of the barometrical measures of the elastic force became negative at that temperature.

In a similar manner M. Bettancourt made experiments on the strength of the vapour from alcohol of spirit of wine; constructing the curve and deducing the requisite analytical formula. This curve had likewise a point of inflexion at about 88° of Reaumur, the second differences in the table of barometrical measures becoming then negative. From a comparison of the experiments on the vapour of water with those on the vapour of alcohol, a remarkable conclusion was derived: for it appeared that, after the first 20° of Reaumur, the strength of the vapour of spirit of wine was to that of the vapour of water, nearly in the same constant ratio of 23 to 10, or 7 to 3, for any one and the same degree of heat. Thus, at the temperature of 40° of Reaumur, the strength of the steam of water is measured by 2·9711 Paris inches in the barometer, and that of vapour of alcohol by 6·9770, the latter being about $2\frac{1}{3}$ times the former.

The equations to the curve of temperature and pressure, denoting the relation between the abscissæ and ordinates, or between the temperature and the elasticity of the vapour, as given by M. Bettancourt, were of the following form.

* To convert Reau. into Fah. multiply Reau. by 9, divide by 4: add to the quotient 32 and the sum is Fah. Reaum. $\frac{\times 9}{4} + 32 = \text{Fah}$.

1. For water, $y = e^{m+lx} - e^{m'+lx} - e^{sx-r} + e^{s'x-r'}$

2. — alcohol, $y = e^{m+lx} + e^{m'+lx} - e^{sx-r} + e^{s'x-r'} - A$.

Where y represents the height of the column of mercury which measures the expansive force, x the corresponding degrees of Reaumur's thermometer, and the other letters certain values which are assigned to them in the investigation.

But M. Prony, in the 2d volume of his *Architecture Hydraulique*, has thrown these equations into a rather more convenient form, though analogous to those of Bettancourt. His formula for the vapour of water is this,

$$y=m\,r_{,}^{x}+m_{,,}r_{,,}^{x}+m_{,,,}r_{,,,}^{x}+m_{iv}r_{iv}^{x}.$$

The method which he followed consisted in satisfying the results between 0° and 80°, by means of the two first terms, and to interpolate by means of the other two, the differences between the observed values, and those computed by the two first terms, from 80° up to 110°. In this manner he succeeded to express so exactly the observations in their whole extent, that the curves of the calculus and the experiments were only distinguishable the one from the other by such little anomalies, as were manifestly the effect of some trifling though inevitable errors in the observations, and in the graduations of the scales in the apparatus. He afterwards employed an equation of three terms, giving to the different coefficients the following values :

$r_{,}$	$= 1{\cdot}172805$	log. $r_{,}$	$=0{\cdot}0692259$
$r_{,,}$	$= 1{\cdot}047773$	log. $r_{,,}$	$=0{\cdot}0202661$
$r_{,,,}$	$= 1{\cdot}028189$	log. $r_{,,,}$	$=0{\cdot}0120736$
$m_{,}$	$= -0{\cdot}00000072460407$	log. $m_{,}$	$=\bar{7}{\cdot}8601007$
$m_{,,}$	$= +0{\cdot}8648188803$	log. $m_{,,}$	$=\bar{1}{\cdot}9369271$
$m_{,,,}$	$= -0{\cdot}8648181057$	log. $m_{,,,}$	$=\bar{1}{\cdot}9369248$

Substituting these several values in the equation

$$y=m_{,}r_{,}^{x}+m_{,,}r_{,,}^{x}+m_{,,,}r_{,,,}^{x},$$

it satisfies not only the numbers employed in its formation, but all the intermediate observations, as may be concluded from the following table, which exhibits to every 10 degrees of Reaumur's thermometer the barometrical results both of observation and the calculus.*

Temperature.	Pressures given by		Anomalies.
	Experim.	Calculus.	
0	0·00in.	0·00in.	0·00 in.
10	0·15	0·24	+0·09
20	0·65	0.69	+0·04
30	1·52	1·51	--0·01
40	2·92	2·95	+0·03
50	5·35	5·42	+0·07
60	9·95	9·62	--0·33
70	16·90	16·57	--0·33
80	28·00	27·92	--0·08
90	46·40	45·87	--0·53
100	71·80	71·94	+0·14
110	98·00	98·36	+0·36

The anomalies are generally much more minute than in the formulæ of four terms: we may therefore regard

* *Table of the Force of Steam at different Temperatures of Fahrenheit's Scale from actual Experiment.* 2 *Hen. Ch.* 518.
(Bettancourt in Prony's Architecture Hydraulique.)

Temperature.	Force in English Inches of Mercury.	Temperature.	Force in English Inches of Mercury.
32	0	162	9.07
42	.08	172	11.0
52	.21	182	14.9
62	.38	192	18.7
72	.58	202	23.7
82	.87	212	29.8
92	1.26	222	37.4
102	1.74	232	46.5
112	2.37	242	57.3
122	3.16	252	69.7
132	4.16	262	83.6
142	5.43	272	97.1
152	7.00	282	108.

the equation just preceding the table, which is more simple than that of Bettancourt, as representing the phenomena and measuring the effects of the expansive force of the steam of water with all desirable accuracy. M. Prony remarks, that the smallness of the coefficient m, will allow the term $m_{,} r_{,}^{x}$ to be neglected in reckoning between 0° and 80°; and thus from the temperature of ice up to that of boiling water, the equation of two terms alone will suffice, that is to say .... $y = m_{,,} r_{,,}^{x} + m_{,,,} r_{,,,}^{x}$.

M. Prony's equation for the vapour of alcohol comprises 5 terms originally: but in most cases three of those terms will give results sufficiently accurate. The numeral values of the coefficients are as below:

$r_{,} = 1{\cdot}11424$	- - - -	log. $r_{,} = 0{\cdot}04697771$
$r_{,,} = 1{\cdot}05714$	- - - -	log. $r_{,,} = 0{\cdot}02413079$
$r_{,,,} = 0{\cdot}79943$	- - - -	log. $r_{,,,} = \bar{1}{\cdot}9027776$
$m_{,} = -0{\cdot}0021293$	- - -	log. $m_{,} = \bar{3}{\cdot}3282330$
$m_{,,} = +0{\cdot}9116186$	- - -	log. $m_{,,} = \bar{1}{\cdot}9598132$
$m_{,,,} = +0{\cdot}2097778$	- - -	log. $m_{,,,} = \bar{1}{\cdot}3217595$
$miv = -1{\cdot}1192671$		

These numbers cause the experiments and calculus to coincide very nearly, when introduced into the equation

$$y = m_{,} r_{,}^{x} + m_{,,} r_{,,}^{x} + m_{,,,} r_{,,,}^{x} + miv.$$

The magnitude of the anomalies will be seen by inspecting the following table.

Temperature.	Pressures given by Experim.	Pressures given by Calculus.	Anomalies.
0	0·00in.	0·00in.	0·00
10	0·47	0·45	−0·02
20	1·52	1·56	+0·04
30	3·49	3·54	+0·05
40	6·90	6·97	+0·07
50	13·05	12·93	−0·12
60	23·65	23·05	−0·50
70	39·30	39·31	+0·01
80	63·80	64·35	+0·55
90	98·00	98·28	+0·28

Thus the formula for the vapour of spirit of wine is found as simple as that for the vapour of water, without ceasing to represent the experiments with all desirable exactness. But more than this, we may retrench one of the variable terms; for in the first degree $m_{,,,} r_{,,,}^{x}$ has no greater value than 0·18, and when x is 2, 3, or any other positive value, this third term may be safely neglected. The equation therefore is reduced to

$$y=m_{,} r_{,}^{x}+m_{,,} r_{,,}^{x}+m\text{iv};$$

a form much more simple than Bettancourt's original equation, and indeed more simple than Prony's improved equation for the vapour of water.

To save the trouble of investigating the strength of the vapour by these formula for every separate case that may occur, we add a table (calculated from these principles) in which the strength of the vapour both of water and of spirit of wine is shewn for every degree of Reaumur's thermometer up to 110°, or for every $2\frac{1}{4}$ degrees of Fahrenheit, from 32 to 280°: the strengths are expressed, not in English or in French inches upon the barometer, but in terms, whose unit is the medium pressure of the atmosphere, supposing that medium equivalent to 29·9

English, or 28 French inches of mercury. The pressure upon a square inch in pounds avoirdupois corresponding to any temperature may be found by multiplying the corresponding number taken from the table by 14·75: and the pressure for any intermediate degree of Fahrenheit may be found pretty nearly, by proportioning, as is usual in tables of Logarithms, &c.

Degrees of Thermometer		Pressure in terms of atmospheric pressure		Degrees of Thermometer		Pressure in terms of atmospheric pressure	
Reau.	Fahr.	Vapour of Water	Vapour of Alcohol.	Reau.	Fahr.	Vapour of Water.	Vapour of Alcohol.
1	34¼	·00063	·00015	33	106¼	·06668	·15656
2	36½	·00124	·00074	34	108½	·07136	·16771
3	38¾	·00192	·00171	35	110¾	·07634	·17949
4	41	·00267	·00299	36	113	·08159	·19193
5	43¼	·00371	·00449	37	115¼	·08714	·20151
6	45½	·00433	·00641	38	117½	·09302	·21898
7	47¾	·00539	·00849	39	119¾	·09921	·23366
8	50	·00621	·01080	40	122	·10611	·24921
9	52¼	·00740	·01333	41	124¼	·11266	·26557
10	54½	·00823	·01608	42	126½	·11994	·28289
11	56¾	·00971	·01832	43	128¾	·12762	·30120
12	59	·01085	·02163	44	131	·13573	·32054
13	61¼	·01221	·02514	45	133¼	·14428	·34098
14	63½	·01384	·02884	46	135½	·15329	·36256
15	65¾	·01521	·03276	47	137¾	·16279	·38538
16	68	·01706	·03689	48	140	·17281	·40931
17	70¼	·01860	·04126	49	142¼	·18338	·43500
18	72½	·02046	·04588	50	144½	·19447	·46193
19	74¾	·02244	·05076	51	146¾	·20609	·49036
20	77	·02454	·05591	52	149	·21835	·52043
21	79¼	·02677	·06136	53	151¼	·23155	·55218
22	81½	·02914	·06711	54	153½	·24524	·58571
23	83¾	·03165	·07319	55	155¾	·25228	·62117
24	86	·03432	·07961	56	158	·27481	·65864
25	88¼	·03715	·08641	57	160¼	·29076	·69671
26	90½	·04014	·09358	58	162½	·30650	·73673
27	92¾	·04331	·10116	59	164¾	·32525	·77167
28	95	·04667	·10917	60	167	·34386	·82337
29	97¼	·05023	·11763	61	169¼	·36345	·86946
30	99½	·05364	·12657	62	171½	·38249	·91467
31	101¾	·05833	·13603	63	173¾	·40572	·96587
32	104	·06219	·14601	64	176	·42849	1·0231

Degrees of Thermometer.		Pressure in terms of atmospheric pressure.		Degrees of Thermometer.		Pressure in terms of atmospheric pressure.	
Reau.	Fahr.	Vapour of Water.	Vapour of Alcohol.	Reau.	Fahr.	Vapour of Water.	Vapour of Alcohol.
65	178¼	·45245	1·0795	88	230	1·4872	3·2548
66	180½	·47765	1·1385	89	232¼	1·5618	3·3806
67	182¾	·50414	1·2004	90	234½	1·6382	3·5099
68	185	·53199	1·2652	91	236¾	1·7176	
69	187¼	·56126	1·3330	92	239	1·8003	
70	189½	·59203	1·4038	93	241¼	1·8851	
71	191¾	·62436	1·4778	94	243½	1·9733	
72	194	·65832	1·5552	95	245¾	2·0643	
73	196¼	·69403	1·6359	96	248	2·1579	
74	198½	·74589	1·7199	97	250¼	2·2539	
75	200¾	·77096	1·8075	98	252½	2·3527	
76	203	·81236	1·8985	99	254¾	2·4533	
77	205¼	·85588	1·9932	100	257	2·5554	
78	207½	·90214	2·0855	101	259¼	2·6587	
79	209¾	·94957	2·1895	102	261½	2·7628	
80	212	1·0000	2·2983	103	263¾	2·8667	
81	214¼	1·0519	2·4074	104	266	2·9735	
82	216½	1·1064	2·5177	105	268¼	3·0711	
83	218¾	1·1634	2·6345	106	270½	3·1691	
84	221	1·2232	2·7527	107	272¾	3·2631	
85	223¼	1·2851	2·8739	108	275	3·3505	
86	225½	1·3500	2·9977	109	277¼	3·4299	
87	227¾	1·4177	3·1236	110	279½	3·5127	

Several curious and in some respects useful consequences might be deduced from these experiments and theorems. M. Bettancourt shews for instance, that the effect of steam engines must, in general, be greater in winter than in summer, owing to the different degrees of temperature in the water of injection. And from the greatly superior strength of the vapour of spirit of wine over that of water, he argues that, by trying other fluids, some may be found, not very expensive, whose vapour may be so much stronger than that of water, with the same degree of heat, that it may be substituted instead of water in the boilers of steam engines, to the great saving in the expence of fuel: nay, he even asserts, that spirit of wine itself might thus be employed in a machine of a

particular construction, which, with the same quantity of fuel, and without any increase of expence in other things, shall produce an effect far superior to what is obtained from the steam of water. Another use of these researches suggested by M. Bettancourt is, to measure the height of mountains by means of a thermometer immersed in boiling water; which he thinks may be done with a precision equal, if not superior, to that of the barometer. But this, being foreign to our present enquiries, cannot be entered upon here: a comparison of the results of this method with some deduced from the more customary process may be seen in Dr. Hutton's Dictionary, vol. II. pa. 756, to which such as are desirous of further information on this point are referred.

Our ingenious countryman Mr. Dalton, of Manchester, is of opinion that M. Bettancourt's deductions are not quite accurate. His chief error consists in having assumed the force of vapour from water of 32° (Fahrenheit) to be nothing; which makes his numbers essentially wrong at that point and in all the lower parts of the scale: and in the higher part, or that which is above 212°, the force is determined too much; owing as Mr. Dalton apprehends, to a quantity of air, which being disengaged from the water by heat and mixing with the steam, increases the elasticity.

Mr. Dalton's first experiments with spirit of wine led him to adopt the same conclusion as M. Bettancourt, with respect to the constant ratio between the force of the vapour from this spirit and that from water; and inferred the same with regard to the vapour from other fluids. But, on pursuing the subject, he concluded that this principle was not true, either with respect to spirit of wine or any other liquid. His experiments upon six different liquids agree in establishing as a general law, "*That the* "*variation of the force of vapour from all liquids is the*

" *same for the same variation of temperature, reckoning* " *from vapour of any given force:* thus, assuming a force " equal to thirty inches of mercury as the standard, it be- " ing the force of vapour from any liquid boiling in the " open air, we find *aqeous* vapour loses half its force by a " diminution of 30 degrees of temperature: so does the " vapour of any other liquid lose half its force by dimi- " nishing its temperature 30 degrees below that in which " it boils; and the like for any other increment or decre- " ment of heat. This being the case, it becomes unneces- " sary to give distinct tables of the force of vapour from " different liquids, as one and the same table is sufficient " for all."

The experiments on which this conclusion rests, are related in the fifth volume of the *Manchester Memoirs:* they may also be seen in the 6th volume of the New Series of *Mr. Nicholson's Journal.* Mr. Dalton has calculated a table of the force of vapour of water from the temperature of 40° below zero of Fahrenheit, to 325° above it. From this table we have extracted the following; in which we have, as before, reduced the force to the medium pressure of the atmosphere for the measuring unit, that the small differences in the results of the English and the Spanish philosopher may be the more readily traced.

Temperature on Fahr.	Force of aqueous Vapour.	Temperature on Fahr.	Force of aqueous Vapour
80°	·0333	212°	1·000
90	·0453	220	1·166
100	·0620	230	1·391
110	·0843	240	1·655
120	·1110	250	1·940
130	·1446	260	2·257
140	·1913	270	2·595
150	·2473	280	2.958
160	·3153	290	3·337
1[illegible]0	·4043	300	3·727
180	·5050	310	4·117
190	·6333	315	4·30[illegible]
200	·7880	320	4·500
210	·9613	325	4·690

The preceding experiments and calculations of Bettancourt, are certainly valuable; but they require to be checked by the very important paper of Mr. Dalton, of Manchester, of which the following is an extract so far as it relates immediately to the theory of the Steam Engine.

Extract from experimental Essays on the Constitution of mixed Gases; on the force of steam or vapour from water and other liquids in different temperatures, both in a Torricellian Vucuum and in air; on evaporation; and on the expansion of gases by heat. By John Dalton. 5 Manch. Trans. 241. 6 Nich. Phil. 257.

THE progress of Philosophical knowledge is advanced by the discovery of new and important facts; but much more when those facts lead to the establishment of *general*

laws. It is of importance to understand that the descent of falling bodies is the same every where on the surface of the earth; but from that and some other particular facts to infer the law of gravitation, or that all matter attracts with a force decreasing as the square of the distance, is a much higher attainment in science. In the train of experiments lately engaging my attention some new facts have been ascertained, which, with others, seem to authorise the deduction of general laws, and such as will have influence in various departments of natural philosophy and chemistry.

As the detail of experiments will be best understood and their application seen, if the laws of principles alluded to be kept in view, it may be proper here to state them; though it must not be understood that they were proceeded upon hypothetically in the direction of those experiments. On the contrary, the first law, which is as a mirror in which all the experiments are best viewed, was *last* detected, and after all the particular facts had been previously ascertained.

1. When two elastic fluids, denoted by *A* and *B*, are mixed together, there is no mutual repulsion amongst their particles; that is, the particles of *A* do not repel those of *B*, as they do one another. Consequently, the pressure or whole weight upon any one particle arises solely from those of its own kind.

2. The force of steam from all liquids is the same, at equal distances above or below the several temperatures at which they boil in the open air: and that force is the same under any pressure of another elastic fluid as it is in vacuo. Thus, the force of *aqueous* vapour of 212° is equal to 30 inches of mercury; at 30° below, or 182°, it is of half that force; and at 40° above, or 252°, it is of double the force; so likewise the vapour from sulphuric ether which boils at 102°, then supporting 30 inches of mercu-

ty, at 30° below that temperature it has half the force, and at 40° above it, double the force: and so in other liquids. Moreover, the force of aqueous vapour of 60° is nearly equal to half inch of mercury, when admitted into a torricellian vacuum; and water of the same temperature, confined with perfectly dry air, increases the elasticity to just the same amount.

3. The quantity of any liquid evaporated in the open air is directly as the force of steam from such liquid at its temperature, all other circumstances being the same.

4. All elastic fluids expand the same quantity by heat: and this expansion is very nearly in the same equable way as that of mercury; at least from 32° to 212°.—It seems probable the expansion of each particle of the same fluid, or its sphere of influence, is directly as the quantity of heat combined with it; and consequently the expansion of the fluid as the cube of the temperature, reckoned from the point of total privation.

Having now stated the chief principles which seem to be established from the following series of facts and observations, I shall proceed to treat of them under the several heads.

On the force of steam or vapour from water and various other liquids, both in a vacuum and in air.

The term *steam* or *vapour* is equally applied to those elastic fluids which, by cold and pressure of certain known degrees, are reduced wholly or in part into a liquid state. Such are the elastic fluids arising from water, alcohol, ether, ammonia, mercury, &c. Other elastic fluids that cannot be reduced, or rather that have not yet been reduced, into a liquid state by the united agency of those two powers, are commonly denominated *gases*. There can scarcely be a doubt entertained respecting the reducibility

of all elastic fluids of whatever kind into liquids; and we ought not to despair of effecting it in low temperatures and by strong pressure exerted upon the unmixed gases. However unessential the distinction between the gases and vapours may be in a chemical sense, their *mechanical* action is very different. By increasing the quantity of any gas in a given space the force of it is proportionally increased; but increasing the quantity of any liquid in a given space does not at all affect the force of the vapour arising from it. On the other hand, by increasing the temperature of any gas a proportionate increase of elasticity ensues; but when the temperature of a liquid is increased, the force of vapour from it is increased with amazing rapidity, the increments of elasticity forming a kind of geometrical progression, to the arithmetical increments of heat.—Thus, the ratio of the elastic force of atmospheric air of 32°, to that at 212°, is nearly as 5 : 7; but the ratio of the force of aqueous vapour proceeding from water of 32° and 212°, is as 1 : 150 nearly.

The object of the present essay is to determine the utmost force that certain vapours, as that from water, can exert at different temperatures. The importance hitherto attached to this enquiry has arisen chiefly from the consideration of steam as a mechanical agent; and this has directed the attention more especially to high temperatures. But it will appear from what follows that the progress of philosophy is more immediately interested in accurate observations on the force of steam in low temperatures. Different authors have published accounts of their experiments on the force of steam: I have on a former occasion (Meteorological Essays, page 134) given a table of forces for every 10° from 80° to 212°. The author of the article "Steam," in the Encyclopedia Britannica, has done the same from 32° to 280°: and M. Bettancourt, in the "Memoirs des scavans etrangeres" for 1790, (see Hut-

ton's Math. Diction. page 755) has given tables on the subject, both for vapour from water and spirit of wine, also from 32° to 280°. But these two authors, having assumed the force of vapour from water of 32° to be nothing, are essentially wrong at that point and in all the lower parts of the scale; and in the higher part, or that above 212°, they determine the force too much: owing as I apprehend to a quantity of air, which being disengaged from the water by heat and mixing with the steam, increases the elasticity.—In a question of such moment it seemed therefore desirable to obtain greater accuracy.

My method is this: I take a barometer tube perfectly dry, and fill it with mercury just boiled, marking the place where it is stationary; then having graduated the tube into inches and tenths by means of a file, I pour a little water (or any other liquid the subject of experiment) into it, so as to moisten the whole inside; after this I again pour in mercury, and, carefully inverting the tube, exclude all air: the barometer by standing some time exhibits a portion of water, &c. of $\frac{1}{8}$ or $\frac{1}{10}$ of an inch upon the top of the mercurial column; because being lighter it ascends by the side of the tube; which may now be inclined and the mercury will rise to the top manifesting a perfect vacuum from air. I next take a cylindrical glass tube open at both ends, of 2 inches diameter and 14 inches in length; to each end of which a cork is adapted, perforated in the middle so as to admit the barometer tube to be pushed through and to be held fast by them; the upper cork is fixed two or three inches below the top of the tube, and is half cut away so as to admit water, &c. to pass by; its service being merely to keep the tube steady. Things being thus circumstanced, water of any temperature may be poured into the wide tube, and thus made to surround the upper part or vacuum of the barometer, and the effect of temperature in the production of vapour

within can be observed from the depression of the mercurial column. In this way I have had water as high as 155° surrounding the vacuum: but as the higher temperatures might endanger a glass apparatus; instead of it I used the following:—

Having procured a tin tube of four inches in diameter and two feet long, with a circular plate of the same soldered to one end having a round tube in the centre like the tube of a reflecting telescope, I got another smaller tube of the same length soldered into the larger, so as to be in the axis or centre of it: the small tube was open at both ends, and on this construction water could be poured into the large vessel to fill it, whilst the central tube was exposed to its temperature. Into this central tube I could insert the upper half of a syphon barometer, and fix it by a cork, the top of the narrow tube also being corked; thus the effect of any temperature under 212° could be ascertained, the depression of the mercurial column being known by the ascent in the exterior leg of the syphon.

The force of vapour from water between 80° and 212° may also be determined by means of an air-pump; and the results exactly agree with those determined as above. Take a Florence flask half filled with hot water, into which insert the bulb of a thermometer; then cover the whole with a receiver on one of the pump-plates, and place a barometer gage on the other: the air being slowly exhausted, mark both the thermometer and barometer at the moment ebullition commences, and the height of the barometer gage will denote the force of vapour from water of the observed temperature. This method may also be used for other liquids. It may be proper to observe, the various thermometers used in these experiments were duly adjusted to a good standard one.

After repeated experiments by all these methods, and a careful comparison of the results, I was enabled to digest the following table of the force of steam from water in all the temperatures from 32° to 212°.

Two important enquiries still remained, the first to determine the force of steam from water above 212° and below 32°; the second, to determine the comparative forces of vapour from other liquids. These enquiries seemed independent of each other; notwithstanding which I found them in reality connected.

Upon examination of the numbers in the table, within the limits just mentioned, there appears something like a geometrical progression in the forces of vapour; the ratio, however, instead of being constant, is a gradually diminishing one: thus the

Force at 32°	= ,200 inch.		
		17. 50	Ratios.
122	= 3. 500		
		8. 57	
212	= 30. 000		

If we divide these ratios, according to observation, they will stand thus;

Force at 32°	= ,200 inch.		
		4. 550	Ratios.
77	= ,910		
		3. 846	
122	= 3. 500		
		3. 214	
167	= 11. 250		
		2. 666	
212	= 30. 000		

If we divide these again they become,

Force at	32°	=	,200	inch.	
				2. 17	
	54½	=	,435		
				2. 09	
	77	=	910		
				2. 00	
	99½	=	1. 820		
				1. 92	
	122	=	8. 500		Ratios.
				1. 84	
	144½	=	6. 450		
				1. 75	
	167	=	11. 250		
				1. 67	
	189½	=	18. 800		
				1. 59	
	212	=	30. 000		

By another division we obtain the ratios for every 11¼° of temperature from 32° to 212°, as under:

Force at	32°	=	,200	inch	
				1. 485	
	43¼	=	,297		
				1. 465	
	54½	=	,435		
				1. 45	
	65¾	=	,630		
				1. 44	
	77	=	,910		
				1. 43	
	88¼	=	1, 290		
				1. 41	
	99½	=	1. 820		
				1. 40	
	110¾	=	2. 540		
				1. 38	
	122	=	3. 500		Ratios.
				1. 36	
	133¼	=	4. 760		
				1. 35	
	144½	=	6. 450		

		1. 33
155¾	= 8. 550	
		1. 32
167	= 11. 250	
		1. 30
178¼	= 14. 600	
		1. 29
189½	= 18. 800	
		1. 27
200¾	= 24. 000	
		1. 25
212	= 30. 000	

Thus it appears that a ratio having a uniform decrease nearly takes place; and we may therefore extend the table of forces at both extremes, without the aid of experiment, to a considerable distance. Thus assuming the ratios for each interval of a 11¼° below 32° to be, 1.500, 1.515, 1.530, 1.545, &c. and for each interval above 212° to be 1.235, 1.220, 1.205, 1.190, 1.175, 1.160, 1.145, 1.130, &c. we can extend the table many intervals of temperature, and determine all the intermediate degrees by interpolation. This method may be relied upon as a near approximation; however it does not supercede the expediency of determination by experiment; though that is much more difficult above 212°, and below 32°, than in the intermediate degrees; because it is difficult to procure a steady heat above 212°; and below 32° the variation of force becomes so small as to elude minute discrimination. It will appear from what follows that the extension of the table by this method above 212° is in all probability accurate, or very nearly so, for 100° or more.

Table of the force of vapour from water in every temperature from that of the congelation of mercury, or 40° below zero of Fahrenheit, to 325°.

Temperature.	Force of vap. in inches of mercury.	Temperature.	Force of vap. in inches of mercury.	Temperature.	Force of vap. in inches of mercury.
-40°	,013	36°	,229	78°	,940
-30	,020	37	,237	79	,971
-20	,030	38	,245	80	1. 00
-10	,043	39	,254	81	1. 04
—	—	40	,263	82	1. 07
0	,064	41	,273	83	1. 10
1	,066	42	,283	84	1. 14
2	,068	43	,294	85	1. 17
3	,071	44	,305	86	1. 21
4	,074	45	,316	87	1. 24
5	,076	46	,328	88	1. 28
6	,079	47	,339	89	1. 32
7	,082	48	,351	90	1. 36
8	,085	49	,363	91	1. 40
9	,087	50	,375	92	1. 44
10	,090	51	,388	93	1. 48
11	,093	52	,401	94	1. 53
12	,096	53	,415	95	1. 58
13	,100	54	,429	96	1. 63
14	,104	55	,443	97	1. 68
15	,108	56	,458	98	1. 74
16	,112	57	,474	99	1. 80
17	,116	58	,490	100	1. 86
18	,120	59	,507	101	1. 92
19	,124	60	,524	102	1. 98
20	,129	61	,542	103	2. 04
21	,134	62	,560	104	2. 11
22	,139	63	,578	105	2. 18
23	,144	64	,597	106	2. 25
24	,150	65	,616	107	2. 32
25	,156	66	,635	108	2. 39
26	,162	67	,655	109	2. 46
27	,168	68	,676	110	2. 53
28	,174	69	,698	111	2. 60
29	,180	70	,721	112	2. 68
30	,186	71	,745	113	2. 76
31	,193	72	,770	114	2. 84
—	—	73	,796	115	2. 92
32	,200	74	,823	116	3. 00
33	,207	75	,851	117	3. 08
34	,214	76	,880	118	3. 16
35	,221	77	,910	119	3. 2[illegible]

Table continued.

Temperature.	Force of vap. in inches of mercury.	Temperature.	Force of vap. in inches of mercury.	Temperature.	Force of vap. in inches of mercury.
120°	3. 33	166°	10. 96	212°	30. 00
121	3. 42	167	11. 25	—	—
122	3. 50	168	11. 54	213	30. 60
123	3. 59	169	11. 83	214	31. 21
124	3. 69	170	12. 13	215	31. 83
125	3. 79	171	12. 43	216	32. 46
126	3. 89	172	12. 73	217	33. 09
127	4. 00	173	13. 02	218	33. 72
128	4. 11	174	13. 32	219	34. 35
129	4. 22	175	13. 62	220	34. 99
130	4. 34	176	13. 92	221	35. 63
131	4. 47	177	14. 22	222	36. 25
132	4. 60	178	14. 52	223	36. 88
133	4. 73	179	14. 83	224	37. 53
134	4. 86	180	15. 15	225	38. 20
135	5. 00	181	15. 50	226	38. 89
136	5. 14	182	15. 86	227	39. 59
137	5. 29	183	16. 23	228	40. 30
138	5. 44	184	16. 61	229	41. 02
139	5. 59	185	17. 00	230	41. 75
140	5. 74	186	17. 40	231	42. 49
141	5. 90	187	17. 80	232	43. 24
142	6. 05	188	18. 20	233	44. 00
143	6. 21	189	18. 60	234	44. 78
144	6. 37	190	19. 00	235	45. 58
145	6. 53	191	19. 42	236	46. 39
146	6. 70	192	19. 86	237	47. 20
147	6. 87	193	20. 32	238	48. 02
148	7. 05	194	20. 77	239	48. 84
149	7. 23	195	21. 22	240	49. 67
150	7. 42	196	21. 68	241	50. 50
151	7. 61	197	22. 13	242	51. 34
152	7. 81	198	22. 69	243	52. 18
153	8. 01	199	23. 16	244	53. 03
154	8. 20	200	23. 64	245	53. 88
155	8. 40	201	24. 12	246	54. 68
156	8. 60	202	24. 61	247	55. 54
157	8. 81	203	25. 10	248	56. 42
158	9. 02	204	25. 61	249	57. 31
159	9. 24	205	26. 13	250	58. 21
160	9. 46	206	26. 66	251	59. 12
161	9. 68	207	27. 20	252	60. 05
162	9. 91	208	27. 74	253	61. 00
163	10. 15	209	28. 29	254	61. 92
164	10. 41	210	28. 84	255	62. 85
165	10. 68	211	29. 41	256	63. 76

Table continued.

Temperature.	Force of vap. in inches of mercury.	Temperature.	Force of vap. in inches of mercury.	Temperature.	Force of vap. in inches of mercury.
257°	64. 82	280°	88. 75	303°	115. 32
258	65. 78	281	89. 87	304	116. 50
259	66. 75	282	90. 99	305	117. 68
260	67. 73	283	92. 11	306	118. 86
261	68. 72	284	93. 23	307	120. 03
262	69. 72	285	94. 35	308	121. 20
263	70. 73	286	95. 48	309	122. 37
264	71. 74	287	96. 64	310	123. 53
265	72. 76	288	97. 80	311	124. 69
266	73. 77	289	98. 96	312	125. 85
267	74. 79	290	100. 12	313	127. 00
268	75. 80	291	101. 28	314	128. 15
269	76. 82	292	102. 45	315	129. 29
270	77. 85	293	103. 63	316	130. 43
271	78. 89	294	104. 80	317	131. 57
272	79. 94	295	105. 97	318	132. 72
273	80. 98	296	107. 14	319	133. 86
274	82. 01	297	108. 31	320	135. 00
275	83. 13	298	109. 48	321	136. 14
276	84. 35	299	110. 64	322	137. 28
277	85. 47	300	111. 81	323	138. 42
278	86. 50	301	112. 98	324	139. 56
279	87. 63	302	114. 15	325	140. 70

On Vapour from Ether, &c.

We come now to the consideration of vapour from other liquids. Some liquids are known to be more evaporable than water; as liquid ammonia, ether, spirit of wine, &c. others less; as, quicksilver, sulphuric acid, liquid muriate of lime, solution of potash, &c. and it appears that the force of vapour from each, in a vacuum, is proportionate to its evaporability. M. Bettancourt maintains that the force of vapour from spirit of wine is in a constant ratio to that from water at all temperatures; namely, as 7 to 3 nearly. My first experiments with spirits of wine led me to adopt this conclusion, and naturally suggested that the force of vapour from any other liquid would bear a constant ratio to that of water. The principle, however, is

not true, either with regard to spirit of wine or any other liquid. Experiments made upon six different liquids agree in establishing this as a general law; namely, *that the variation of the force of vapour from all liquids is the same for the same variation of temperature, reckoning from vapour of any given force:* thus assuming a force equal to thirty inches of mercury as the standard, it being the force of vapour from any liquid boiling in the open air, we find *aqueous* vapour loses half its force by a diminution of 30° of temperature; so does the vapour of any other liquid lose half its force by diminishing its temperature 30° below that in which it boils; and the like for any other increment or decrement of heat. This being the case, it becomes unnecessary to give distinct tables of the force of vapour from different liquids, as one and the same table is sufficient for all. But it will be proper to relate the experiments on which this conclusion rests.

Experiment on Sulphuric Ether.

The ether I used, boiled in the open air at 102 degrees. I filled a barometer tube with mercury, moistened by agitation in ether. After a few minutes a portion of ether rose to the top of the mercurial column, and the height of the column became stationary. When the whole had acquired the temperature of the air in the room, 62°, the mercury stood at 17.00 inches, the barometer at the same time being 29.75. Hence the force of vapour from ether at 62° is equal to 12.75 inches of mercury, which accords with the force of aqueous vapour at 172°, temperatures which are 40° from the respective boiling points of the liquids. By subsequent observations I found the forces of the vapour from ether in all the different temperatures from 33° to 102° exactly corresponded with the forces of aqueous vapour of the like range, namely, from 142° to

212°: the vapour from ether depresses the mercury about six inches in the temperature of 32 degrees.

Finding that ether *below* the point of ebullition agreed with water below the said point, I naturally concluded that ether *above* the point would give the same force of vapour as water above it; and in this I was not disappointed; for, upon trial it appeared that what I had inferred only from analogical reasoning respecting the force of aqueous vapour above the boiling point, actually happened with that from ether above the said point. And ether is a much better subject for experiment in this case than water, because it does not require so high a temperature.

I took a barometer tube of 45 inches in length, and having sealed it hermetically at one end, bent it into a syphon shape, making the legs parallel, the one that was close being nine inches long, and the other thirty-six. Then conveyed two or three drops of ether to the end of the closed leg, and filled the rest of the tube with mercury, except about ten inches at the open end. This done, I immersed the whole of the short leg containing the ether into a tall glass containing hot water; the ether thus exposed to a heat above the temperature at which it boils, produced a vapour more powerful than the atmosphere, so as to overcome its pressure and raise a column of mercury besides, of greater or less length according to the temperature of the water. When the water was at 147° the vapour raised a column of 35 inches of mercury, when the atmospheric pressure was 29.75: so that vapour from ether of 147 degrees is equivalent to a pressure of 64.75 inches of mercury; agreeing with the force of aqueous vapour of 257 degrees, according to the preceding estimation: in both cases the temperatures are 45 degrees above the respective points of ebullition. In all the temperatures betwixt 102 degrees and 147 degrees the forces of ethereal vapour corresponded with those of aqueous vapour,

as per table, betwixt 212 degrees and 257 degrees. I could not reasonably doubt of the equality continuing in higher temperatures; but the force increases so fast with the increase of heat, that one cannot extend the experiments much farther without tubes of very inconvenient lengths. Being desirous however to determine the force of the ethereal vapour experimentally up as high as 212°, I contrived to effect it as follows:—Took a syphon tube, such as described above, only not quite so long, and filled it in the manner above mentioned, with ether and mercury, leaving about ten inches at the top of the tube vacant; then having graduated that part into equal portions of capacity, and dried it from ether, I drew out the end of the tube to a capillary bore, cooled it again so as to suffer the internal atmospheric air to be of the proper density, and suddenly sealed the tube hermetically, thus inclosing air of a known force in the graduated portion of the tube. Then, putting that part of the tube containing ether into boiling water, vapour was formed which forced the mercurial column upwards and condensed the confined air, till at length an equilibrium took place. In this way I found 8.25 parts of atmospheric air of the force 29.5 were condensed into 2.00, at the same time a perpendicular column of 16 inches of mercury in addition pressed upon the vapour. Now the force of elastic fluids being inversely as the space, we have 2.00 : 29.5 : : 8.25 : 121.67 inches = the force of the air within; to which adding 16 inches, we obtain 137.67 = the whole force sustained by the vapour, measured in inches of mercury. The force of aqueous vapour, at the same distance beyond the boiling point, or 322°, is equal to 137.28, per table. Thus it appears that in every part of the scale on which experiments have been made, the same law of force is observable with the vapour of ether as of water.

Experiments on Spirit of Wine.

By boiling a small portion of the spirit I used (about one cubic inch) in a phial, the thermometer stood at 179 degrees at the commencement; but by continuing the ebullition it acquired a greater heat. The reason is, the most evaporable part of the spirit flies off during the process of heating, and the rest being a weaker compound, requires a stronger heat. The true point of ebullition, I believe, was nearly 175 degrees. The force of the vapour from this spirit at the temperature of 212 degrees, I found both by an open syphon tube and one hermetically sealed with atmospheric air upon the mercurial column, as with ether, to be equal to 58 and an half inches of mercury. This rather exceeds the force of aqueous vapour at an equal distance from the boiling point; but it is no more than may be attributed to unavoidable little errors in such experiments. In a barometer tube the spirituous vapour at 60 degrees, over the mercury, depresses the column about 1.4 or 1.5 inches; which is something less than the due proportion; one cause of this may be the evaporability of spirits, which in operating on small quantities, quickly dissipates part of their strength." *(Dalton.)*

The principles and manner of operation of the steam-engines of Savery, Newcomen and Cawley, and of Watt, may be understood from the following brief explanations and remarks, which I extract from Hornblower's communication to Gregory. 2 *Nich.* 354.

1. Savery's engine.—Let there be a sucking pipe with a valve opening upwards at the top, communicating with a close vessel of water, not more than thirty-three feet above the level of the reservoir, and the steam of boiling water be thrown on the surface of the water in the vessel, it will force it to a height as much greater than 33 feet as

the elastic force of the steam is greater than that of air; and if the steam be condensed by the injection of cold water, and a vacuum thus formed, the vessel will be filled from the reservoir by the pressure of the atmosphere; and the steam being admitted as before, this water will also be forced up; and so on successively.

Such is the principle of the first steam-engine, said by the English to be invented by the *Marquis of Worcester;* while the French ascribe it to *Papin:* though we believe the fact is that *Brancas*, an Italian, applied the force of steam ejected from a large eolopile as an impelling power for a stamping-engine so early as 1629. The hint so obscurely exhibited in the marquis of Worcester's Century of Inventions, was carried into effect by captain Savery.

2. NEWCOMEN'S.—If the steam be admitted into the bottom of a hollow cylinder, to which a solid piston is adapted, the piston will be forced upwards by the difference between the elastic forces of steam and common air; and the steam being then condensed, the *piston will descend by the pressure of the atmosphere*, and so on successively. This is the principle of the steam-engine first contrived by Messieurs *Newcomen* and *Cawley*, of Dartmouth. This is sometimes called the atmospherical engine, and is commonly a forcing-pump, having its rod fixed to one end of a lever, which is worked by the weight of the atmosphere upon a piston at the other end, a temporary vacuum being made below it by suddenly condensing the steam, that had been admitted into the cylinder in which this piston works, by a jet of cold water thrown into it. A partial vacuum being thus made, the weight of the atmosphere presses down the piston, and raises the other end of the straight lever, together with the water, from the well. Then immediately a hole is uncovered in the bottom of the cylinder, by which a fresh quantity of hot steam rushes in from a boiler of water below it, which

proving a counterbalance for the atmosphere above the piston, the weight of the pump-rods, at the other end of the lever, carries that end down, and raises the piston of the steam-cylinder. The steam hole is then immediately shut, and a cock opened for injecting the cold water into the cylinder of steam, which condenses it to water again, and thus making a vacuum below the piston, the atmosphere again presses it down and raises the pump-rods, as before; and so on continually.

3. WATT'S.—The great features of improvement made by Mr. *Watt* upon the engine of Newcomen and Cawley are, as Mr. Nicholson remarks, first, that the elasticity of the steam itself is used as the active power in this engine;* and secondly, that besides various other judicious arrangements for the economy of heat, he condenses the steam, not in the cylinder, but in a separate vessel.

In the cylinder or syringe, concerning which we have spoken, in mentioning the engine of Newcomen, let us suppose the upper part to be closed, and the piston-rod to slide air tight through a collar of leathers. In this situation, it is evident that the piston might be depressed by throwing the steam upon its upper furface, through an aperture at the superior end of the cylinder. But if we suppose the external air to have access to the lower surface of the piston, we shall find that steam no stronger in its elasticity than to equal the weight of the atmosphere would not move the piston at all; and consequently that this new engine would require much denser steam, and consume much more fuel than the old engine. The remedy for this evil is to maintain a constant vacuum beneath the piston. If such a vacuum were originally produced by steam, it is certain that its permanency could

* The Piston being forced downward, not by the pressure of the atmosphere, as in Newcomen's, but by the elastic force of Steam thrown on the top of the piston.

not be depended on, unless the engine contained a provision for constantly keeping it up. Mr. Watt's contrivance in his simplest engine is as follows: The steam is conveyed from the boiler to the upper part of the cylinder through a pipe, which also communicates occasionally with the lower part, and beyond that space with a vessel immersed in a trough of water; in which vessel the condensation is performed by an injected stream of cold water. This water is drawn off, not by an eduction-pipe but by a pump, of which the stroke is sufficiently capacious to leave room for the elastic fluid, separated during the injection, to follow and be carried out with the injection water. Suppose now the piston to be at its greatest elevation, and the communication from the boiler to the upper as well as to the lower parts of the cylinder to be opened. The steam will then pass into the whole internal part of the engine, and will drive the air downwards into the condenser, and thence through the valves of the air-pump. In this situation, if the communication from the boiler to the lower part of the cylinder be stopped, and an injection be made into the condenser, a vacuum will be produced in that vessel, and the steam contained in the lower part of the cylinder and communication pipe will expand itself with wonderful rapidity towards the condenser, so that in a period of time too minute to be appreciated, the whole of the steam beneath the piston will be practically condensed. The steam which continues to act above the piston will immediately depress it into the vacuum beneath; at the same time that by connection with the external apparatus the piston of the air-pump also descends in its barrel. When the stroke is nearly completed downwards, the requisite part of the apparatus shuts the communication with the boiler, opens that between the upper and lower parts of the cylinder and condensing vessel, and turns the injection-cock. At this ve-

ry instant the piston loses its tendency to descend, because the steam presses equally on both surfaces, and continues its equality of pressure while the condensation is performed. It therefore rises; the injection is stopped; and the air-pump making its stroke, suffers the injection water and a considerable part of the elastic fluid to pass through its lower valve. The vacuum is thus kept up through the whole internal capacity of the engine. As soon as the piston has reached the upper part of the cylinder, the communication to the under part of the cylinder is stopped, and that with the boiler opened, as before; the consequence of which is, that the piston again descends; and in this manner the al ernations repeatedly take place.

The principal augmentation of power in this engine, compared with that of Newcomen, arises from the cylinder not being cooled by the injection water, from its being practicable to use steam, which is more powerful than the pressure of the atmosphere, and from the employing of this steam both to elevate and to depress the piston. In general, these engines are worked by steam, which would support a column of four or five inches of mercury besides the pressure of the atmosphere, and sometimes more; for Mr. Nicholson says, he has sometimes seen the gage as high as eight inches. Mr. Watt has made several successive modifications and additions to the engine just described, some of which will be further spoken of in the course of this article.

4. It has been customary, when treating of steam-engines, to present several theorems for the computation of their power and effects. But as all which has hitherto been advanced on these points seems to us very vague and unsatisfactory, we shall not delude the student with an appearance of mathematical accuracy, when it is so far from being attained. It is obvious enough that the absolute power of a steam-engine is in the compound ratio of

the area of the piston, the pressure upon each inch of it, the length of the stroke, and the number of strokes in any assigned time: but the pressure upon any portion of the piston can only be ascertained by experiment and observation, and that with difficul y, because of our uncertain methods of estimating friction and other species of resistance; while judicious observations would with much less labour determine the work actually performed, either when the steam-engine works pumps, or gives motion to any kind of mills. The quantity of water raised by pumps in a given time may soon be estimated: and when the alternating motion of the steam-piston is converted into a rotatory one, the real effect the engine is capable of producing may be ascertained by observing the velocity with which a given weight is raised when suspended from the axle to which the rotation is first given.

The usual method of estimating the effects of engines by what are called "horse powers" must inevitably be very fallacious, unless all engineers could agree as to the quantity of work which they would arbitrarily assign to *one* horse, and in that case the term would manifestly be nugatory. It may also be observed, that in determining the comparative value of different steam-engines, it is not sufficient to compare the quantities of work each will perform in equal times; for the expence of erection, the probability of repairs being more or less frequent on account of the complexness or simplicity of construction, and the quantities of fuel consumed by each, must likewise be taken into the account.*

In giving a clear explanation of the principle of this machine, (Watt's) it will be necessary to deviate from the

* Boulton and Watt have fixed and determined what they mean by a horse-power, viz. a power that will raise 33000lbs. one foot high in a minute, at a medium rate of working the engine.

T. C.

precise disposition of the parts as they are usually put together: but in fig. 1. of the plate, this deviation is very little, and represents a single engine. A the cylinder in which the piston moves, B the steam-pipe, D the condenser, E the discharging-pump, F a bottom common to the pump and condenser, in which is an occasional communication by a hanging valve at F: *g* is a valve to be lifted by the engine at every stroke, for the purpose of condensing the steam; *h* is a valve placed outside the cistern (of which *x x x x* is a section on purpose to shew the contents), but communicates only with the condenser by a pipe passing through the side of the cistern, and is inserted at the side of the condenser; *i* is a valve to be lifted by the engine, and opens a communication between the cylinder and the condenser; *k* is a valve to be lifted by the engine, and opens a communication between the lower part of the cylinder and the steam-pipe; and *l* is also a valve of the same kind, opening a passage from the boiler to all parts of the engine.

The piston-rod, which is here broken off at *m*, is connected by a chain to the lever or beam, which is supported on a wall of good masonry, with proper pivot-blocks for support to the gudgeons; and as this kind of engine is usually employed for pumping water, another set of chains at the other end of the beam is appropriated to connect to the pump-rods.

Then to set the engine to work, the first thing is to lift the three valves *i*, *k*, and *l* (for which there are apparatus too minute to lay down on this scale); these being opened, the steam occupies every cavity and crevice of the engine, and in a little while displaces all the air in the cylinder, condenser, &c. which is discharged at the valve *h*: this valve is always covered with water in a small cistern attached to the side of the large one; for it is hardly in the power of art to fit it to that degree of accuracy as to

& Watts

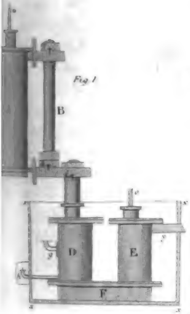
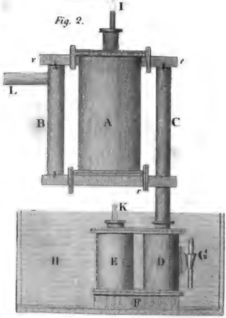


Fig. 1

Boulton & Watts

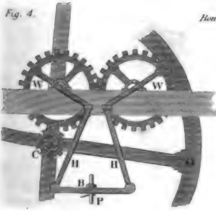
Double Engine.

Fig. 2.



parallel motion.

Fig. 4.



Boulton & Watts Barometer Guage.

Fig. 3.

ensure its tightness: but here the air is discharged at first setting the engine to work; and this valve is called the *blowing* valve. When the cylinder and other vessels are properly heated and the air discharged, which is well known by a very smart crackling noise at that valve, like a violent decrepitation of salt in a fire:* these valves *k* and *i* are to be shut; and after waiting a few seconds, gently open the valve *i*: and if the engine does not move, the injection valve *g* must be opened a little;† and if the engine does not move, then the operation of blowing must be performed again, though but for a few seconds, and the engine in general will go off smartly.

In all engines on this principle, it is necessary that the parts appropriated to condensation of the steam, should be kept as cold as possible, and that those parts intended for the operation or passage of the steam be kept as hot as possible: hence the discharging pump and condenser are placed in a cistern of cold water kept constantly full, and a little running away; and if the injection-valve is placed low in this cistern, it will take the water in the coldest state.

As the condenser is immersed in water to be kept cold, so the cylinder should if possible be immersed in steam to be kept hot: for which purpose Mr. Watt formerly used a casing round the cylinder, and at the top and bottom; and this would have been attended with very beneficial effects if it did not enlarge the steam surface, and expose it to a more rapid condensation when it ought to

* This noise is occasioned by the air being all gone, and the water producing a sudden and rapid condensation of the steam.

† The valve *i* being opened, there is a passage made from the cylinder to the condenser; but on account of long blowing, the sides of the condenser become hot, and the water in the cistern hot likewise: so that the condensation must needs be very slow, even at the first injection of the water into the condenser.

be preserved; for to have the vacuum as perfect as possible, it is necessary that the cylinder be kept up to such a temperature as to prevent the least condensation on the internal surface either above or below the piston: because, if the sides of the cylinder were to be wet, as in the common atmospherical engine, the vacuum would be vitiated, as it is there occasioned by this wetness or moisture gradually forming to steam, which the outside casing prevents, being filled with steam from the boiler. But if it were possible to cover this outward case with any sort of substance which would entirely prevent the transmission of heat *for that casing*, it would supercede the use of the casing altogether, and would apply with more advantage to the cylinder itself. But we do not know of any substance which will not admit this transmission more or less. They who wish for information on this subject may find it in count Rumford's Essays.

The first circumstance of importance to the proportion and disposition of the several parts, is the solidity of the vessels and the perfection of the joints. Copper tubes are apt to be unsound at the seams, and other parts which are required to be bent out of a right line; and iron castings, which require any particular sort of stay in the moulding to keep the core from the outside, as these stays are made mostly of wrought iron, they contract more in cooling than the cast-iron does about them, even so as to become loose sometimes; in such cases, it is unutterably perplexing to find out the places or cause of this defection; the joints are suspected for the most part, but even remaking them sometimes proves no amendment; and this must be the cause in general why one engine from the same patterns is better or worse than others. And we have reason to fear that this matter of complaint is on the increase; for self-interest has so powerful a preponderancy, especially in the metropolis, that

we shall despair of having these objects regarded as they were formerly; semblance being for the greatest part the order of the day.

Mr. Watt has adopted a gage (very improperly* called a barometer,) to indicate the degree of vacuum in his engines; and we deem it of important consequence to the well-going of the engine, the profit of the proprietor, and the credit of the engineer; yet in many engines in London we see this important instrument either out of repair, or wholly laid aside. The form is given at fig. 3. They have been made of glass; but if the quicksilver is not very pure, the alloy with which the venders of this article adulterate it is by constant action brought to the surface, and that and the vapour together make the tube so foul that no precision can be obtained. Iron therefore is the best material: both parts of the tube should be correctly of one diameter, or else the result will be erroneous. This tube must communicate with the condenser by a small copper pipe, and a stop-cock be placed between the gage and condenser. The index in this instrument is a light deal rod, which is put into the shorter tube; and quicksilver being poured into it within three inches of the end, the rod is put into the tube, and it floats on the quicksilver. It is almost needless to remark, that the graduations on this instrument must be inverted with regard to those of a single tube.

Perhaps it should have been noticed before, that the rod of the discharging pump is connected with the lever at some point determinable by the length of the stroke; and in this figure it rises with the piston, and brings up the air and water with it, both of which are discharged at the branch *p*, in which is a hanging valve opening outward.

The valve *l*, the office of which is to open or shut the communication between the cylinder and the boiler, is so

* I do not see why. T. C.

particularly connected with the working gear, that by altering the place of a pin it is shut sooner or later, as occasion requires; and when the piston has proceeded half way down, if this valve is shut at that instant, the piston is carried through the remainder of the stroke, partly by the momentum it has already acquired, and partly by the remaining expansion of the steam, which notwithstanding its growing rarer and rarer, is sufficient with its momentum to complete the stroke.

We have observed, that in order to give action to the engine at its first onset, and indeed at every succeeding stroke, the valve *i* is to be lifted. This valve is kept down by a weight equal to the pressure of the atmosphere, added to the elasticity of the steam above that pressure; there being a vacuum beneath it, and the action of the steam upon it. Hence, in large engines it requires a great force to lift it up.

WATT's *double Engine.** We have represented the mode of working this engine at fig. 2. where we must deviate largely from the practical application, in order to give a comprehensive explanation. A is the cylinder, as in the single engine; B is a pipe appropriated to deliver the steam from the boiler through the branch L; from thence it enters the cylinder alternately by the valves *v*, *w*, both opening towards the steam side. The pipe C has also two valves, one at the upper end of the pipe in the box *t*, and one which we must designate at the joint *r*, both opening toward the cylinder. The condenser D has a blowing-valve, like the former figure in the single engine; but the injection is made by a cock G, which has a pipe reaching near the bottom of the cistern; and when the engine is at work this cock is always open, and the injection always running in, because the steam is constantly

* Which Hornblower derides. T. C.

coming from the cylinder either above or below the piston, and its operation is as follows:

When the air is blown out of the engine, and the piston happens to be in its upper situation, the valve *v* on the steam side is lifted, and the valve *r* on the exhausting side is opened: the exhausting-valve *r* takes the steam from below the piston, while the steam by the valve *v* enters on the upper surface, and a stroke is made; and at the instant the piston comes to its place at the bottom of the cylinder, these valves are both shut, and the valves *w* and *t* are opened, and the upward stroke commences, and so on alternately.

It must be observed here that, whereas the piston in the single engine is pendant on the lever by the chains lying in the arch of the inner end, this must be connected by a mode that shall render the rod rigid in its action upward; for which purpose there is a system of transverse joints which compel the rod to a motion parallel to itself. At the other end of the beam or lever is a rod which connects the motion of the engine to a fly; and Mr. Watt has chosen to do this by a very ingenious application of one wheel fixed on the axis of the fly, and another fixed on the rod that is connected to the lever, by which means the fly makes one entire revolution, while the engine makes but one stroke; and thus the fly makes as many revolutions as the engine does strokes; but we are inclined to give the preference to a simple crank with a fly of such weight as shall have the desired momentum with less velocity, simplicity being ever a desideratum in the construction of machinery.

Cartwright's Engine. A steam engine has been invented by Mr. Edmund Cartwright, which has as much merit as can possibly be attributed to a gentleman engaged in the pursuit of mechanical studies for his own amusement. Mr. Cartwright has two very important desiderata

in view, a tight piston and a vacuous condenser; that is to say, a condenser from which the atmospheric air is excluded: to accomplish which it is made of as thin copper as it will admit, exposing a large surface to the water, then the steam internally comes in contact with the metal of the same temperature, and hence the condensation. We wish it were possible to put this grand design into a decided effect: but from some particulars we have observed in the doctrine of condensation, no method yet explored will obtain so rapid a condensation as actual contact with the water: we do not account for this by any chemical affinity, but by the exposure of surface; for the experiment has been tried to our satisfaction, that when the jet was not in a dispersive state, the condensation was tardy and inactive; and if it were possible to disperse the jet into a mist, we should obtain the most prompt condensation possible.

But still we do not conceive an instantaneous condensation is absolutely necessary; for if it is performed during the time of the required stroke, that is all which is wanted. We cannot say whether Mr. Cartwright has succeeded ultimately to this point or not.

We remember to have seen preparations for an apparatus for this mode of condensing some years since, by an assemblage of taper pipes of about a quarter of an inch diameter, exposing a surface of between 90 and 100 feet to a 20-inch cylinder; but an accident from a rude hand prevented its application for that time, and we do not think it was ever resumed.

The packing of Mr. Cartwright's piston is composed of a series of segments of brass, the arches of which conform exactly to the circumference of the cylinder; these are to be laid on the verge of the piston so as to make one entire disk, then another and another stratum super stratum until the designed thickness is acquired:

then to keep these segments in constant tendency to the place of action, there are a set of springs very nicely contrived to act on the concave edge, which, no doubt, will keep them to their work; but the difficulty is how to preserve the fit at the junctures: it is impossible for the segment of a small circle to become the segment of a larger circle*. But we do not suppose Mr. Cartwright to have intended this metallic packing to compensate the irregular figure of the steam-vessel, for it is impossible; beside, Mr. Cartwright's notions of accuracy would never suffer him to admit a steam-vessel to his engine which was not a perfect cylinder; in which case these segments may have but little wear, though, if they were of metal in any degree softer than the cylinder, the dust which will find its way there, would wear away the cylinder so as to be sensibly detrimental: added, that this packing could never apply to a double engine. It, however, serves as a very elegant specimen of the inventor's inclination to accurate working.

Since the above was written, we have seen an engine of Mr. Cartwright's at a tan-yard near Horsley-Down,† which gives great satisfaction to the proprietor. The piston, by the account of the tender of the engine, has not even been looked at for many months, nor has he any indications that it will be necessary for many more. This account receives strong confirmation by the appearance of the quantity of condensed steam which is discharged from the engine every stroke, which, as it is not effected in the common way (by injection), can be very exactly estimated.

* Admitting that these segments wear away on the outer arches, the inner arches must recede from the centre, and therefore will be one continued deduction from the entire circle.

† Near London.

Its construction is very simple, and it performs its operations very smoothly and effectually.*

The preceding is a tolerably correct though brief account of Savary's, Newcomen's, Watt's and Cartwright's engines: but it will in my opinion be of use to state under various modes of expression the same general facts, that the distinctive characters, and the successive improvements of the principal steam engines may become familiar to the reader. The subject is new in this country, and is extremely important. I have already given all the preliminary knowledge relating to the power of steam that bears upon the question; and I mean in the course of this and the next number to give all the knowledge necessary to a full understanding of the theory of the Steam Engine. The following brief history I extract from Professor Playfair's angry review of Gregory and Hornblower's account of Steam engines; but as I have nothing to do with the illiberal remarks of the latter, or the tart replies of the Professor, I insert no more than relates to the history of Mr. Watt's discoveries and improvements. Edinb. Rev. for Jan. 1809.

"The first idea of the steam-engine is found in the writings of that celebrated projector, the Marquis of Worcester, who, in the year 1663, published a small tract, entitled, "A Century of Inventions," consisting of short

* Mr. Cartwright's contrivance for preserving the parallel motion of the piston-rod, at the same time that it communicates the rotatory motion to the fly, is very ingenious, and is therefore shewn in the plate fig. 3. where P is the top of the piston-rod, upon which is screwed a transverse bar B: to the ends of this bar, at equal distances from the top of the piston-rod, are attached the two equal connecting rods H, H, which as the piston rises and falls turn the cranks and the two equal wheels W, W; these two equal wheels work into each other, and one of them drives the pinion C upon the same axis as the fly-wheel O; thus communicating the rotatory motion to the other parts of the machinery. (Hitherto from Hornblower's account. T. C.

heads or notices of schemes, many of them obviously impracticable, which at various times had suggested themselves to his very fertile and warm imagination. No contemporary record exists to illustrate or verify his description of the contrivance which we presume to call a steam-engine, or to inform us where, and in what manner, it was carried into effect; though it is evident, from his account, that he had actually constructed and worked a machine that raised water by steam. His description of the method is short and obscure; but inclines us to think, contrary to what many have supposed, that the force of his engine was derived solely from the *elasticity* of steam; and that the *condensation* of steam by cold, was no part of his contrivance. This last, we believe, was the invention of Captain Savary, who, in 1696, published an account of his machine, in a small tract entitled the *Miner's Friend*, having erected several engines previous to that period. In these engines the alternate condensation and pressure of the steam took place in the same vessel into which the water was first raised, from a lower reservoir, by the pressure of the atmosphere, and then expelled into a higher one, by the elastic force of strong steam.

Steam, it must be observed, was thus employed merely to produce a vacuum, and to supply the strength that was applied, for a like effect, to the sucker or piston of an ordinary pump; and it was a great step to have discovered a method of bringing the air to act in this manner by the application of heat to water, without the assistance of mechanical force.

The next essential improvement was made by Newcomen, for which he obtained a patent in 1705. It consisted in separating the parts of the engine in which the steam was to act, from those in which the water was to be raised; the weight of the atmosphere being employed only for the purpose of pressure, and the steam for that

of first displacing the air, and then forming a vacuum by condensation. Newcomen was thus enabled to dispense with the use of steam of great and dangerous elasticity, to work with moderate heats, and to remove at least some part of the causes of wasteful and ineffectual condensation. To him we are indebted for the introduction of the steam cylinder and piston, and for their connection with the pump by means of the main lever with its rods and chains, to which we might add several other subordinate contrivances, which do great credit to his ingenuity.

Still, however, the machine required the constant attendance of a man to open and shut the cocks at the proper intervals, for the alternate admission of steam and cold water: and although traditional report attributes the invention of the mechanism by which the engine was made to perform this work itself, to the ingenuity of an idle boy, we know that the contrivance was first perfected by Mr. Henry Beighton, in 1717, who also improved the construction of several other parts of the engine. From this time to the year 1764, there seems to have been no material improvement in the structure of the engine, which still continued to be known by the appellation of Newcomen's, or the atmospheric engine. The boilers, however, had been removed from under the cylinder in some of the larger engines, and the cylinder had been fixed down to a solid basis. Still the steam was condensed *in* the cylinder; the hot water was expelled by the steam; the piston was pressed down by the weight of the atmosphere, and kept tight by being covered with water. It was moreover considered as necessary that the injection cistern should be placed on high, in order that the water might enter with great force. It had been found by experience, that the engine could not be loaded with advantage, with more than seven pounds on each

square inch of the piston; and the inferiority of that power to the known pressure of the atmosphere, was, without due consideration, imputed wholly to friction. The bulk of water when converted into steam was very erroneously computed; the quantity of fuel necessary to evaporate a given quantity of water was not even guessed at; whether the heat of steam is accurately measured by its temperature was unknown; and no good experiment had been made to determine the quantity of injection water necessary for a cylinder of given dimensions. In a word, no man of science in this country had considered the subject since Desaguliers; and his writings, in many respects, tended more to mislead than instruct.

Such was the state of matters, when, fortunately for science and for the arts, Mr. Watt, then a mathematical instrument-maker at Glasgow, undertook the repair of the model of a steam engine belonging to the university. In the course of his trials with it, he found the quantity of fuel and injection water it required much greater in proportion than they were said to be in large engines; and it soon occurred to him, that this must be owing to the cylinder of this small model exposing a greater surface, in proportion to its contents, than larger cylinders did. This he endeavoured to remedy, by making his cylinders and pistons of substances which conducted heat slowly. He employed wood, prepared on purpose, and resorted to other expedients, without producing the desired effect in any remarkable degree. He found, also, that all attempts to produce a greater degree of exhaustion, or a more perfect vacuum, occasioned a disproportionate expenditure of steam. In reflecting upon the causes of these phenomena, the recent discovery, that water boiled in an exhausted receiver at low degrees of heat, (certainly not exceeding 100 degrees of Fahrenheit, but probably, when the vacuum was perfect, much lower) occurred to him:

and he immediately concluded, that, to obtain any considerable degree of exhaustion, the cylinder and its contents must be cooled down to 100 degrees at least; in which case, the reproduction of steam in the same cylinder must be accompanied with a great expense of heat, and consequently of fuel. He next endeavoured to ascertain the temperature at which water boils when placed under various pressures; and, not having any apparatus at hand by which he could make his experiments under pressures less than that of the atmosphere, he began with trying the temperature of water boiling under greater pressures; and by laying down a curve, of which the *abscissæ* represented the temperatures, and the *ordinates* the pressures, he found the law by which the two are connected, whether the pressure be increased or diminished.

Observing, also, that there was a great error in Desaguliers' calculation of the bulk of water when converted into steam, and that the experiment on which he founded his conclusion was in itself fallacious, he thought it essential to determine this point with more accuracy. By a very simple experiment with a Florence flask, which our limits will not allow us to detail, he ascertained, that water, when converted into steam under the ordinary pressure of the atmosphere, occupies about eighteen hundred times its original space.

These points being determined, he constructed a boiler in such a manner, as to show by inspection, with tolerable accuracy, the quantity of water evaporated in any given time; and he also ascertained by experiment the quantity of coals necessary to evaporate a given quantity of water.

He now applied his boiler to the working model above mentioned; when it appeared that the quantity of steam expended at every stroke, exceeded many times what was sufficient to fill the cylinder: and deducing from

thence the quantity of water required to form as much steam as would supply each stroke of the engine, he proceeded to examine how much cold water was used for injection, and what heat it gained; which, to his very great surprise, he found to be many times the number of degrees which could have been communicated to it by a quantity of boiling water equal to that of which the steam was composed. Suspecting, however, that there might be some fallacy in these deductions, he made a direct experiment to ascertain the degree of heat communicated by steam to water; when it clearly appeared, that one part of water, in the form of steam, at 212 degrees, had communicated about 140 degrees of heat to six parts of water. The fact, thus confirmed, was so contrary to all his previous conceptions, that he at first saw no means of explaining it. Dr. Black indeed had, some time before, made his discovery of latent heat; but Mr. Watt's mind being otherwise engaged, he had not attended sufficiently to it, to make himself much acquainted with the doctrine: but upon communicating his observations to the doctor, he received from him a full explanation of his theory; and this induced him to make further experiments, by which he ascertained the latent heat of steam to be above 900 degrees.

The causes of the defects of Newcomen's engines were now evident. It appeared that the steam could not be condensed so as to form an approximation to a vacuum, unless the cylinder, and the water it contained, were cooled down to less than 100 degrees; and that, at greater degrees of heat, the water in the cylinder must produce steam, which would in part resist the pressure of the atmosphere. On the other hand, when greater degrees of exhaustion were attempted, the quantities of injection water required to be increased in a very great ratio; and

this was followed by a proportionate destruction of steam on refilling the cylinder.

Mr. Watt now perceived, that to make an engine in which the destruction of steam should be the least possible, and the vacuum the most perfect, it was necessary that the cylinder should condense no steam on filling it, and that, when condensed, the water, forming the steam, should be cooled down to 100 degrees, or lower. In reflecting on this desideratum, he was not long in finding that the cylinder must be preserved always as hot as the steam that enters it; and that, by opening a communication between this hot cylinder when filled with steam, and another vessel exhausted of air, the steam, being an elastic fluid, would rush into it, until an equilibrium was established between the two vessels; and that if cold water, in sufficient quantity, were injected into the second vessel, the steam it contained would be reduced to water, and no more steam would enter until the whole was condensed.

But a difficulty arose—How was this condensed steam and water to be got out of the second vessel without letting in air? Two methods presented themselves. One was, to join to this second vessel (which, after him, we shall call *the condenser)* a pipe, which should extend downwards more than 34 feet perpendicular, so that the column of water contained in it, exceeding the weight of the atmosphere, would run out by its own gravity, and leave the condenser in a state of exhaustion, except in so far as the air, which might enter with the steam and injection water, should tend to render the exhaustion less perfect: this air he proposed to extract by means of a pump. The second method which occurred, was to extract both air and water by means of a pump, or pumps; which would possess the advantage over the other, of being applicable in all situations. This latter contrivance was

therefore preferred; and is known by the common name of the Air-pump. There still remained some defects unremedied in Newcomen's cylinder. The piston in that engine was kept tight by water; much of which passing by the sides, injured the vacuum below, by its evaporation; and this water, as well as the atmosphere which came into contact with the upper part of the piston and sides of the cylinder at every stroke, tended materially to cool that vessel. Mr. Watt removed these defects, by applying oils, wax, and fat of animals, to lubricate his piston and keep it tight: he put a cover on his cylinder (with a hole in it made air and steam tight, for the piston rod to pass through,) and employed the elastic force of steam to press upon the piston: he also surrounded the cylinder with a case containing steam, or a case of wood, or of other non-conducting substance, which should keep it always of an equable temperature.

The improvement of Newcomen's engine, so far as the saving of steam and fuel was concerned, was now complete in Mr. Watt's mind; and in the course of the following year, 1765, he executed a working model, the effect of which he found fully to answer his expectations. It worked readily with ten and an half lib. on the inch, and was even capable of raising fourteen lib.; and did not require more than one third of the steam, used in the common atmospheric engine, to produce the same effect. Indeed, the principle of keeping the vessel, in which the elasticity of the steam is exerted always hot, and that in which the condensation is performed always cold, is in itself perfect. For the steam never coming in contact with any substance colder than itself until it had done its office, no part is condensed until the whole effect has been obtained in the cylinder; and when it has acted there, it is so condensed in the separate vessel that no resistance remains: accordingly, the barometer proves a vacuum,

nearly as perfect as by the exhaustion of the air-pump. The whole of the steam and heat is usefully employed; and the contrivance appears scarcely to admit of improvement.

Such is the history of this valuable invention, which we have extracted from Dr. Black and Professor Robison's testimonials, who were privy to Mr. Watt's discovery; as well as from some early letters of his own to confidential friends, to which we have had access.

We have entered thus minutely into the subject, from a desire to do that justice which is due to Mr. Watt, by showing that this great improvement was not the effect of accident, or of casual observation, but the result of deep reflection, of great ingenuity, and much philosophical investigation.

It did not, at the early period we have been speaking of, escape him, that great benefit might be derived from the direct application of the power of steam to driving mills, instead of using it to raise water to act on a wheel, as had heretofore been done; and with this view, he invented and executed the model of a steam wheel, for giving a circular motion to an axis.

His occupations in the business of a civil engineer which he had now taken up, perhaps also the indifferent state of his health, his want of funds, and his apprehension of the prejudices and opposition he might have to encounter, prevented his applying for a patent for the invention we have described, until the year 1769. He had, we believe, previous to, or about that time, erected an engine for his friend Dr. Roebuck of Kinneil, near Borrowstounness, which, upon a large scale confirmed his expectations; the proportionate saving of fuel being from two thirds to three fourths of that of engines on Newcomen's construction. Dr. Roebuck, whose spirit for enterprise and improvement in the arts is well known, foresaw all the advantages likely to result from this invention, and be-

came associated in the prospects which it opened. But some of his own projects having failed, he soon after disposed of his interest to Mr. Boulton, the celebrated founder of Soho manufactory, with whose aid Mr. Watt, in 1774, solicited and obtained an act of parliament for the extension of the term of his patent for twenty-five years; and the business of making steam engines was soon after commenced by the firm of Boulton and Watt.

In executing his invention on a large scale, Mr. Watt felt the necessity of improving the construction of several of the parts of Newcomen's engine. With this view, he induced Mr. Wilkinson to erect an apparatus for boring the cylinders with more precision than had hitherto been done; he adopted a new mode of constructing the piston and screwing down the packing, and secured the rod in the piston in a more perfect manner; he introduced puppet valves into the steam boxes or nozles, instead of the old sliding regulators; he used better means of opening these valves, and added various improvements in the working gear; he suspended the working beam, so that the centre of motion was below the centre of gravity, instead of being above it, as in the old engines; and he improved the mode of setting the boilers on the grates, as well as the apparatus for keeping the boilers regularly supplied with water.

He introduced also into some of his earliest reciprocating engines, the principle of using the steam to act expansively, which he had discovered so early as the year 1769.*

* This appears by a letter from him to his friend the late Dr. Small, of Birmingham, dated Glasgow, 28th May, 1769; of which the following is an extract.

'I mentioned to you a method of still doubling the effect of 'the steam, and that tolerably easy, by using the power of steam 'rushing into a vacuum, at present lost. This would do little more

The character of his engines being now fully established by the erection of several large ones in Cornwall, and other parts of the kingdom, Mr. Watt recurred to his favourite idea of applying the power of steam to produce motions round an axis.

He had, upon trial, found practical objections to the steam wheel described in his patent; and a second one which he had contrived was also given up; for, upon very full consideration of the subject, it appeared to him, that the object would be better attained by deriving the rotative motion from the rectilinear motion of the piston in the reciprocating engine.

Something of this kind had been attempted by others. An atmospheric engine had been employed at Hartley coalery, in Northumberland, as early as 1768, to draw coals out of a pit. It had a toothed sector on the end of the working beam, working into a trundle, which, by means of two pinions with ratchet wheels, produced a rotative motion, in the same direction, by both the ascending and descending stroke of the arch; and, by shifting the ratchets, the motion could be reversed at pleasure. This engine had no fly-wheel, and went sluggishly and irregularly. Who the inventor was, we do not know.

A patent was taken out in 1769, by a gentleman of the name of Stewart, for an engine which produced a rotative

'than double the effect, but it would too much enlarge the vessels 'to use it all. It is peculiarly applicable to wheel engines, and 'may supply the want of a condenser where force of steam only is 'used: for, open one of the steam valves, and admit steam until 'one fourth of the distance between it and the next valve is filled 'with steam; shut the valve, and the steam will continue to expand, and to press round the wheel with a diminishing power, 'ending in one fourth of its first exertion. The sum of the series 'you will find greater than one half, though only one fourth steam 'was used. The power will indeed be unequal; but this can be 'remedied *by a fly*, or several other ways.'

motion, by a chain going round a pully, and also round two barrels furnished with ratchet wheels, with a weight suspended to the free end of the chain, which served to continue the motion during the return of the engine. In 1778, Mr. Matthew Washbrough also obtained a patent for communicating a rotative motion from the steam engine, by a method which was virtually the same as that at Hartley; only, he had added a fly-wheel, which we believe was then for the first time employed in the steam engine, though it is evident, from the letter we have quoted from Mr. Watt to Dr. Small, that the former had conceived the idea long previous to this period. Two or three of these engines were erected; but, owing to the defective mode of communicating the motion, were subject to such irregularities and accidents, as rendered them of little use.

The idea of communicating motion from the beam of the steam engine to a crank, in the same manner as is done in the common foot-lathe, had, as we are informed, early occurred to Mr. Watt; but we believe he did not seriously set about reducing his ideas to practice until the year 1778 or 1779. In the first model he then made, in order to equalize the power, two cylinders, acting upon two cranks were fixed upon the same axis, at an angle of 120 degrees from each other; and a weight was placed upon the circumference of the fly-wheel, at an angle of 120° from each of the cranks; which weight was to be so adjusted, as to act when neither of the cranks could do so, and consequently to render the power nearly equal. This model performed to satisfaction; but Mr. Watt having neglected to take out a patent immediately, the essential part of the contrivance was communicated, as we understand, by a workman employed to make the model, to the persons engaged about one of Washbrough's engines; and a patent was taken out for the application of the crank

by the engineer there employed. This did not dishearten Mr. Watt; and, without troubling himself with setting aside a patent which, so long as it continued attached to the common atmospheric engine, could do him little harm, he set about other modes of effecting the same thing; and, in 1781, took out a patent for several new methods of applying the vibrating or reciprocating motion of steam engines to produce a continued rotative motion round an axis; one of which was that beautiful contrivance of the revolving motion of one wheel round another. These and the crank were indifferently used in his engines, without any molestation on the part of the piratical patentee.

This, however, was only a part of what Mr. Watt saw to be necessary, in order to perfect this application of the steam engine. The steam had hitherto been used only to press down the piston, which was returned by a weight at the opposite end of the beam, so that the power of the steam may be said to have been inactive during that period. Mr. Watt remedied this, by applying the power of the steam to press the piston down, as well as to press it up, thus forming alternately a vacuum above and below the piston. This he called *the double engine;* and, in fact, it doubled the power exerted within the same cylinder. He had long had in his mind the idea of this improvement; and had even produced a drawing of it to the house of commons in 1774, at the time he procured the act to prolong his original patent; but the first he executed was, we believe, at Soho in the year 1781 or 1782, and the first public exhibition of it at the Albion Mills a few years later.

About the same period, finding double chains or racks and sectors very inconvenient for communicating the motion of the piston rod to the angular motion of the beam, he invented and applied what has been called the *parallel*

motion, one of the most ingenious and most perfect contrivances in mechanics.

To prevent irregularities in the speed of the engine, arising from variations in the quantum of power used at different intervals in the works to which it was applied, he made an application of the centrifugal force of what is called the *governor*, (before used in the wind and water mills) to regulate the admission of the steam; by this means keeping the engine always at an uniform velocity, and diminishing the consumption of steam in proportion to the power exerted; thus giving the finishing stroke to the perfection of the motion of this machine, and rendering its regularity nearly correspondent with that of the pendulum of a clock.

These inventions are detailed amongst many other contrivances, both relative to steam engines, and the applications of their power in two patents, dated 1782 and 1784. Some of these are highly ingenious: a few may have been first ideas, not yet reduced to practice; and others were no doubt inserted for the purpose of guarding against evasion.

Such is the general outline of the improvements introduced by Mr. Watt into the steam engine; but it would lead us too far, to go into the detail of the applications of this power, or to enumerate the advantages which the country has derived from it. We shall content ourselves with observing, that by means of it, many of the principal mines in the kingdom have been kept open, and rendered productive, when otherwise they must have ceased to work. By the construction of the rotative engine, a new era has been introduced into the manufactures of the kingdom; and it has been in a great measure owing to it, that those manufactures have been carried to an extent unprecedented in the history of nations. The merit and success of these improvements, however, created (as

success and merit will always do) an host of imitators and detractors, from whom Messrs. Boulton and Watt, during the greater part of the term of their exclusive privilege, experienced the most harassing and obstinate opposition.

Having given this short history of Mr. Watt's improvements we shall proceed to consider the view that Mr. Gregory and his associate have taken of the same subject. These gentlemen have both animadverted with great severity, and we think, with very little reason, on the mode adopted by Boulton and Watt for describing the force of the steam engine by a comparison with the power of horses. 'What is called,' say they, 'the horses' power, is 'of so fluctuating and indefinite a nature, that it is perfect'ly ridiculous to assume it as a common measure by 'which the force of steam engines and other machines 'should be appreciated.' II. pp. 78. 357.

Now, we are ready to admit, that if nothing more definite were said of any engine than that it did the work of a certain number of horses, this would not convey an idea of its power sufficiently accurate for many of the purposes of science. It might, however, be accurate enough for many of the purposes of common life. Now, if the thing wanted was an approximate and popular standard of comparison, such as might be intelligible to every body, and sufficiently exact for ordinary purposes, it is certain, that a more convenient expression could not easily be found than that which is here referred to. Prior to Mr. Watt's application of the steam engine to produce rotative motion, the great manufactories of the kingdom had their millwork set in motion by the agency of water, of wind, or of horses; and the latter had, for many years, been almost exclusively employed in the breweries and distilleries of the metropolis. It was therefore natural for one who wished to substitute the power of steam for the pow-

er of horses, to state the number of the latter to which the new power, under given conditions, would be equivalent; and it is probable that Boulton and Watt felt that such a mode of comparison would be more intelligible to common apprehensions, than a more accurate and scientific formula. It gave the power of an engine expressed in numbers, of which the ordinary strength of a horse is the unit. This, no doubt, is not in itself very exact, the unit being large, and subject to some variation. Relatively to the purpose for which it was used, it was however sufficiently correct; and on this, as on many similar occasions, a more minute measurement would have been less useful. If a historian would express the interval of time between two different events, he is in general satisfied with counting the number of years; and it would be a useless affectation of accuracy to reckon up the months, days, hours and minutes, that must be added or taken away, in order to measure the aforesaid interval with mathematical exactness. So, also, if a man were to ride post from London to York, it would serve his purpose as well to know the distance of these cities in miles, as in feet, inches, and decimals of an inch.

Boulton and Watt, however, have not left the matter in a state that can be accounted incorrect in any case, but have given to it all the accuracy that can be required, when, from the result of experiments made with the strong horses employed by the brewers in London, they have assumed, as the standard of a horses's power, a force able to raise thirty-three thousand lb. one foot high in a minute; and this, no doubt, was meant to include an allowance of power sufficiently ample to cover the usual variations of the strength of horses, and of other circumstances that may affect the accuracy of the result. This determination, we think, could not be unknown to Mr. Gregory, and certainly not to his coadjutor. If, in forming the esti-

mate just mentioned, the power of a horse is rated, think it is, above the ordinary average, this circums cannot be complained of by the public, as it tends to r sent the advantage of the engines less than it will be f in real practice."

The following *account of* STEAM ENGINES, from gory's Encyclopedia, being connected with the last of this number, I give it, though at the expence of s repetition. T. C.

ENGINE, *steam*. The steam-engine is one of the blest monuments of human ingenuity. It was origin invented by the marquis of Worcester, in the reign Charles II. This nobleman, who appears to have b possessed of much knowledge, with a fertile imaginatio published in 1663, a small book, called "A Century Inventions," giving an account of a hundred discover or contrivances of his own; but the descriptions of man of them are altogether unintelligible.

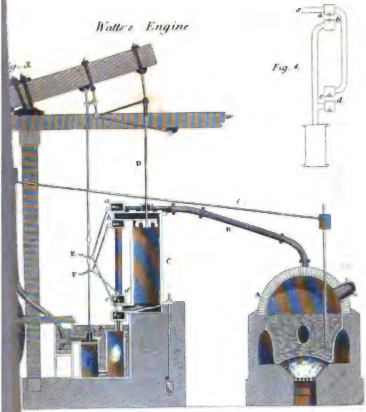
Among them is an account of his invention of raisin water by the force of steam, which, now that we are pos sessed of the engine, appears to agree very well with it construction. But as there is no plate to accompany his description, we are entirely unacquainted with the particular mode in which he applied the power of steam. It does not appear, however, that he met with sufficient encouragement; and this useful discovery was long neglected.

Towards the end of the century, captain Savary, a person of great ingenuity, having probably seen the account of the marquis of Worcester's invention, was convinced of its practicability, and succeeded in constructing a machine of this kind. He obtained a patent for the invention, and erected several steam-engines, which he described in a book entitled "The Miner's Friend," published in 1696.

Watts's Engine

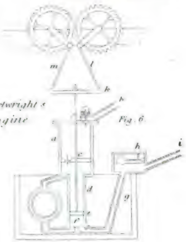
Fig. 3.

Fig. 4.



Cartwright's Engine

Fig. 6.



The following is the description of his machine, as improved by himself:

A (Plate fig. 1) is a strong boiler, built in a furnace for generating steam. From the top of this boiler there proceeds a pipe, b, which conveys the steam into another strong vessel, r, called the receiver. This pipe has a cock at c, called the steam-cock. In the bottom of the receiver is a pipe S, which communicates with the rising-pipe H n k, the lower end of which is immersed in the well from which the water is to be raised. Immediately below the place where the pipe S enters the rising-pipe, there is a valve, n, opening upwards. A similar valve is also placed at i, above the pipe S. Lastly, there is a pipe e, which branching off from the rising-pipe, enters the top of the receiver. This pipe has also a cock, d, called the injection-cock. The mouth of the pipe e, has on the end f a nozzle, pierced full of holes, pointing from a centre in every direction. The keys of the two cocks c and d, are united by the handle h, called the regulator.

The mode of operation is as follows: Let the regulator be so placed, that the steam-cock c be open, and the injection-cock d shut: put water into the boiler A, and make it boil. The steam from it will enter the pipe b, and fill the receiver, first driving out the air which it before contained; a considerable quantity of steam will be at first condensed by the cold sides of the receiver; but it being at length warmed, the steam will proceed into the rising-pipe, lifting up the valve i. When this is perceived to be the case, by the rising-pipe feeling warm, and hearing the valve i rattle, the communication is now to be cut from the boiler, by shutting the steam-cock c, the injection cock d being also shut. The receiver now gradually cools, and the steam included in it condenses into water. When this is the case, as the air was at first driven out by the steam, and cannot return again, all the cocks being shut,

a vacuum is formed in the receiver; consequently, there is nothing to counterbalance the pressure of the atmosphere, which acting upon the water in the well, forces it up the rising-pipe, and fills the receiver. The steam-cock is now opened; and the steam from the boiler rushing in with great violence, presses upon the surface of the water in the receiver, and forcing it through the pipes, into the rising-pipe, causes it to shut the valve n, and open the other valve i; and, provided the steam be sufficiently strong, will force it up the rising-pipe to the top k, where it is delivered. The cock c is kept open until all the water be driven out of the receiver, and it is again filled with steam. The regulator is now applied, which shuts the steam-cock, whilst at the same time it opens the injection-cock. The rising-pipe being still full of water, a stream of cold water proceeds through the pipe e, and enters the receiver in a shower. This instantly condenses the steam in the receiver, and produces a vacuum as before; in consequence of which, the water from the well is again forced up by the external pressure of the atmosphere, and the receiver is again filled with water. The regulator is then turned, which shuts the injection-cock and opens the steam-cock, which permits the steam from the boiler to press upon the water, and again force it up the rising-pipe. This operation filling the receiver with water by means of a vacuum produced in it, and forcing it up the rising-pipe by the pressure of the steam from the boiler, is constantly repeated, by merely turning the regulator, which shuts and opens the steam-cocks and injection-cocks alternately.

This construction of the steam-engine is extremely simple, and might perhaps be successfully applied for some purposes. But it has several considerable defects. It may readily be apprehended, that the action of the direct steam on any definite surface (such, for example, as

a square inch) will be accurately equal to the re-action of the water which is forced up; and consequently, that Savary's engine will require steam more elastic than the air of the atmosphere, in every case except where the water is raised no higher than it can be by the vacuum that is produced, and the pressure of the atmosphere. When the water is forced up through the rising-pipe, every square inch of the boiler must sustain a pressure equal to a column of water an inch square, and of the height of the pipe above the boiler. This, therefore, requires very strong vessels, and several accidents happen by their bursting when the safety valve is loaded too much.

But the greatest defect of this machine is the great waste of steam, and consequently of fuel. For when the steam is admitted to the top of the cold water in the receiver, it is condensed with great rapidity; and the water does not begin to yield to its pressure, until its surface is so hot, as not to condense any more steam: it now descends; but as by that, a new part of the side of the receiver is exposed to the steam, more is condensed, so that a condensation of the steam is going on all the while the water is descending. This too must necessarily be rerepeated every stroke, as the receiver is cooled every time it is filled with water.

Mr. Savary succeeded in raising water to small heights, and erected several engines in different parts of England; but he could make nothing of deep mines. Many attempts have been made to correct these defects, but hitherto without much success.

In the beginning of the eighteenth century, Newcomen, an ironmonger or smith, and Crawly, a glazier at Dartmouth, in Devonshire, first conceived the project of applying a piston with a lever, and other machinery. They were contented to share the profits of the invention with

Savary, who procured a patent for it in 1705, in which they were all three joined.

Fig. 2, exhibits a section of Newcomen's engine: a is the boiler, built in brick-work. In the top of the boiler is a steam-pipe, c, communicating with the cylinder, b, which is of metal, and is bored very truly. The lower aperture of this pipe is shut by the plate n, which is ground very flat, so as to apply very accurately to the whole circumference of the orifice. This plate is called the regulator, or steam-cock, and it turns horizontally round an axis o, which passes through the top of the boiler, and is fitted by grinding to the socket, so as to be steam-tight. It is opened and shut by a handle fixed to its axis.

In the cylinder b is a solid piston, p, well fitted into it, and made air-tight by a packing of leather or soft rope, well filled with tallow; and for greater security, a small quantity of water is kept above the piston.

The piston-rod d is suspended by a chain, which is fixed to the upper extremity of the arched head e of the great lever, or working-beam, e f g, which turns on the gudgeon f. There is a similar arched head g, at the other end of the beam; to the upper extremity of which is fixed a chain, carrying the pump-rod h, which raises the water from the mine.

The load on this end of the beam is made to exceed considerably the weight of the piston at the other extremity.

At a small height above the top of the cylinder, is a cistern called the injection-cistern, i. From this descends the injection-pipe, k, which enters the bottom of the cylinder, and terminates in a nozzle pierced with holes. This pipe has a cock, l, called the injection-cock.

At the opposite side of the cylinder, a little above its bottom, there is a lateral pipe m, turning upwards at the

extremity; and there covered by a clack-valve, called the snifting-valve, which has a little dish round it, to hold water for keeping it air-tight.

There proceeds also from the bottom of the cylinder, a pipe g, of which the lower end is turned upwards, and is covered with a valve r. This part is immersed in a cistern of water, called the hot-well, and the pipe itself is called the eduction-pipe.

Lastly, the boiler is furnished with a safety valve, called the puppet-clack, in the same manner as in Savary's engine. This valve is generally loaded with one or two pounds on the square inch, so that it allows the steam to escape when its elasticity is one-tenth greater than that of the atmosphere. Thus all risk of bursting the boiler is avoided, the pressure outwards being very moderate.

When the cistern for the injection-water i, cannot be supplied by pipes from some more elevated source, water is raised by the machine itself. A small lifting-pump s, is worked by a rod v, suspended from a small arch upon the great beam; this forces water through the pipe t into the injection-cistern.

The parts of the engine being now described, the operation is as follows:

Suppose the piston and lever in the position represented in the plate, and the water in the boiler in a state of ebullition, the steam and injection-cocks being shut. Having opened the steam-cock n, the steam from the boiler will immediately rush in, and flying all over the cylinder, will mix with the air.

Much of it will be condensed by the cold surface of the cylinder and piston, and the water produced from it will trickle down the sides, and run off by the eduction-pipe. This condensation and waste of steam will go on until the whole cylinder and piston be made as hot as boiling-water.

When this happens, the steam will begin to issue through the snifting-valve, slowly at first, and cloudy, being mixed with much air; but, by degrees, it will become more transparent, having carried off the greatest part of the air which filled the cylinder.

When the attendant perceives that the blast at the snifting-valve is strong and steady, and the boiler is supplied with a steam of proper strength, appearing by the renewal of its discharge at the safety-valve, which had stopped while the cylinder was filling, he shuts the steam-cock n, and opens the injection-cock l. The pressure of water in the injection-pipe forces some out into the cylinder, which condenses the steam and forms a partial vacuum, as explained above.

The upper side of the piston is now exposed to the whole pressure of the atmosphere, which, not being counterbalanced on the under side, will act with its whole force on the piston, and, provided there be not too much weight on the other end, will raise it, the piston going to the bottom of the cylinder.

When the piston has gone down as low as necessary, the injection-cock is shut, and the steam-cock opened. The steam, which has been accumulating above the water in the boiler, during the time of the descent of the piston, and is now issuing through the puppet-clack, as soon as the steam-cock is opened, rushes violently into the cylinder, having a greater elasticity than that of the air. It therefore immediately blows open the snifting-valve, through which it drives out the air that had been disengaged from the injection-water.

At the same time, the water which had been injected before, and the condensed steam, run out through the eduction-pipe g, and lifting up the valve r, flow into the hot-well.

By the admission of the steam under the piston, the pressure of the atmosphere on the top is counterbalanced, and the piston is free to move upwards or downwards.

But the other end of the beam being broader, so as to be heavier than the piston, now raises it to the top of the cylinder, whence it is again forced downwards by the pressure of the atmosphere, as soon as a vacuum is formed under it by the admission of the injection-water. In this manner the operation is repeated; the piston being forced down by the weight of the atmosphere, raises the other end of the beam, with whatever is attached to it; and, on the other hand, when the pressure of the atmosphere is counterbalanced by the steam under the piston, the superior weight of the pump-end of the beam brings the piston up again.

We now see the difference between Savary's and Newcomen's engine, in respect to principle. Savary's was an engine that raised water by the force of steam; but Newcomen's raises water entirely by the pressure of the atmosphere; and the steam is employed merely as the most expeditious mode of producing a vacuum, into which the atmospherical pressure may impel the first mover of his machine.

We see also the great superiority of this new machine. We have no need of steam of great and dangerous elasticity; and we operate by means of very moderate heats, and consequently with a much smaller quantity of fuel: and there are no bounds to the power of this machine. How deep soever a mine may be, a cylinder may be employed of such dimensions, that the pressure of the air may exceed in any degree, the weight of the column of water to be raised. And lastly, this form of the machine renders it applicable to almost every mechanical purpose; because a skilful mechanic can readily find a method of converting the reciprocating motion of the working-beam

into a motion of any kind which may suit his purpose. Savary's engine could hardly admit of such a general application, and seems almost restricted to raising water.

Newcomen's engine was first offered to the public in 1705. But many difficulties occurred in the execution of it, which were removed one by one; and it was not till 1712, that the engine seemed to give confidence in its efficacy.

The most exact and unremitting attention was required, to open and shut the cocks precisely at the proper time; for neglect might be ruinous to the machine, by the confined steam beating out the bottom of the cylinder, or allowing the piston to be wholly drawn out of it. Stops were contrived to prevent these accidents; then strings were used to connect the handles of the cocks with the beam, so that they should be turned whenever it was in certain positions. These were gradually changed, and improved into detents and catches of different shapes; at last, Mr. Beighton, a very ingenious and well informed artist, simplified the whole of these subordinate movements, and otherwise very much improved the machine.

The greatest improvement that has since been made on Newcomen's engine, has been in the manner of placing the boiler. Instead of placing it underneath the cylinder, it is built at some distance from it, and sometimes in a separate building.

About 1762, Mr. Watt began to turn his attention to this machine, which he has since brought to so great a degree of perfection.

But before we explain Mr. Watt's engines, it is necessary to premise a short account of the imperfections of the old steam-engines, and their causes.

The steam or vapour which arises from water confined in a close vessel, and heated a few degrees above the point at which it boils in the open air, becomes an elastic fluid,

uniform, and transparent, about half the gravity of atmospheric air, very much greater in bulk than the water of which it is composed, and capable of being again reduced to water when brought into contact with matter of a less degree of heat than itself.

The pressure of the atmosphere, or any equivalent resistance, prevents the production of steam, until the water is heated to 212 degrees of Fahrenheit's thermometer; but when that pressure is removed, or the water is placed in a vessel exhausted of air, steam is produced from it when it is colder than the human blood. On the contrary, if water is pressed upon by air or steam, which are more compressed than the atmosphere, a degree of heat above 212 degrees is necessary for the production of steam; and the difference of heats at which water boils under different pressures, increases in a less proportion than the pressures themselves; so that a double pressure requires less than a double increase of sensible heat.

The experiments which have been published concerning the bulk of water when converted into steam, are erroneous; and the conclusions drawn from them make that bulk greater than it really is. It has been known for some time, that water would boil in an exhausted receiver at a low degree of heat.

If we consider the common steam-engine, we shall find it defective; first, because the vacuum is produced by throwing cold water into the cylinder to condense the steam: that water becomes hot, and, being in a vessel partially exhausted, produces a steam, which in part resists the pressure of the atmosphere upon the piston, and lessens the power of the engine. The second defect is the destruction of steam, which unavoidably happens upon attempting to fill a cold cylinder with that fluid; for the injection-water, at the same time that it condenses the steam, not only cools the cylinder, but remains there until it is extruded at the eduction-pipe by the steam which

is let in to fill the cylinder for the next stroke; and that steam will be condensed into water as fast as it enters, until all the matter it comes in contact with, is nearly as hot as itself.

Every attempt to make the vacuum more perfect by the addition of injection-water, will cool the cylinder more effectually, and cause a greater destruction of steam in the next filling; and if the engine has already a proper load, the destruction of steam will proceed in a greater ratio than the increase of power by the amendment of the vacuum.

Though it appears that the constructors of steam-engines have never investigated these causes, yet they have been so sensible of the effects, that a judicious engineer does not attempt to load his engine with a column of water heavier than seven pounds for each square inch of the area of the piston.

Mr. Watt's improvements are founded upon these, and some other collateral observations. He preserves an uniform heat in the cylinder of his engines, by suffering no cold water to touch it; and by protecting it from the air or other cold bodies, by a surrounding case filled with the steam, or with hot air or water, and by coating it over with substances that transmit heat slowly. He makes his vacuum to approach nearly to that of the barometer, by condensing the steam in a separate vessel, called the condenser; which may be cooled at pleasure without cooling the cylinder, either by injection of cold water, or by surrounding the condenser with it; and generally by both. He extracts the injection-water and detached air from the cylinder or condenser, by pumps, which are wrought by the engine itself; or he blows it out by the steam.

As the inside of the cylinder was in the old engine exposed to the air at every stroke when the piston descended, and was considerably cooled thereby, he incloses the top

of the cylinder by a metal plate, having a hole in it through which the piston-rod works in a collar of leathers; and instead of employing the pressure of the atmosphere to force down the piston, he introduces the steam above the piston, when the vacuum is formed underneath, and employs it to produce this effect: thus making the direct pressure of the steam the moving power, as in the original construction of the engine.

The last great improvement made by Mr. Watt, was his giving an impulse to the piston by the steam, both in descending and ascending, instead of being impelled, as in the old engine, during the descent of the piston only.

Having thus briefly mentioned the principal improvements made in the steam engine by Mr. Watt, we shall proceed to describe one of his engines on the latest construction.

A is the boiler, to which Mr. Watt has paid very great attention. It is generally of an oblong form; and the flame, after striking on its concave bottom, circulates round the sides, and sometimes returns in a pipe through the body of the water before it is suffered to go up into the chimney. In his engines there are commonly two of these boilers, so that one of them may work while the other is repairing. B (Plate fig. 3) is the steam-pipe which conveys the steam to the cylinder C, which is cased, and closed at top by a plate, having a collar of leathers, through which the piston-rod D works. a and c are the steam-valves, through which the steam enters into the cylinder: it is admitted through a, when it is to press the piston downwards, and through c when it presses it upwards. b and d are the eduction-valves, through which the steam passes from the cylinder into the condenser e, which is a separate vessel placed in a cistern of cold water, and which has a jet of cold water continually playing up in the inside of it. f is the air pump, which extracts the air

and water from the condenser: it is worked by the great beam or lever; and the water brought by it from the condenser, after being brought into the hot-well g, is pumped up again by the pump h, and is brought back again into the boiler by the pipe i. k is another pump, also worked by the engine itself, which supplies the cistern in which the condenser is placed, with cold water.

In the old engines, where the working stroke was only downwards, the piston-rod was attached to the beam by chains, which bent round an arch on the end of the beam, in order to make the piston-rod move always in a perpendicular direction. This may be seen in the plate of Newcomen's engine. But in Mr. Watt's engines, where the working-stroke is doubled, that is, both upwards and downwards, chains could not answer this purpose, as, when the piston was forced upwards, they would slacken, and would not communicate the motion to the beam. It was necessary, therefore, that the piston-rod should be fastened to the beam by inflexible bars; but that the stroke might be perpendicular, a particular contrivance was invented by Mr. Watt, which is exhibited in the plate, and which answers the intended purpose admirably. It is usually called the parallel joint, and its nature and construction will be easily understood from the figure. In order to make the engine itself open and shut the steam and eduction-valves, long levers are attached to them, which are moved by the piston-rod of the air-pump E F. This part of the apparatus is called the working-geer, and is so contrived, that the valves may be worked either by hand or by the perpendicular rod. By shutting these valves, the engine may be stopped in an instant.

In order to communicate a rotatory motion to any machinery by the motion of the beam of the steam-engine, Mr. Watt makes use of a very large fly-wheel G; on the axis of which is a small concentric toothed wheel, H. A

similar toothed wheel I, is fastened by straps to a rod coming from the end of the beam, so that it cannot turn round on its axis, but must rise and fall with the motion of the great beam.

A bar of iron connects the centres of these two small toothed wheels, so that they cannot quit each other. When, therefore, the beam raises the wheel I, it must move round the circumference of the wheel H, and turn it together with the fly; and it will be evident, upon consideration, that the fly, driven in this manner, will make two revolutions for every one of the wheel I. This mode of moving the fly, is preferable to a crank; as it goes with twice the velocity. This contrivance is called the sun and planet wheel, from the resemblance of the motion to that of those luminaries.

The valves of this steam-engine are all puppet-valves, as these are found least liable to be out of order.

The mode of operation in Mr. Watt's engine, is as follows:

Suppose the piston at the top of the cylinder, in the situation represented in the plate, and the lower part of the cylinder filled with steam. By means of the handle E, open the steam-valve a, and the eduction-valve d, the levers of which are connected together; there being now a communication between the cylinder and the condenser, the steam instantly rushes into the condenser, leaving the cylinder empty; whilst at the same time the steam from the boiler, entering by the steam-valve a, presses upon the piston and forces it down. As soon as the piston has arrived at the bottom, the steam-valve c, and the eduction valve b, are opened, whilst the valves a and d are shut; the steam therefore immediately rushes through the eduction-valve b, into the condenser, whilst the piston is forced up again by the steam, which is now admitted by the steam-valve c.

Fig. 4, which is a section of the steam-pipes, taken at right angles to that in fig. 3, shews this more distinctly; s is the pipe which conveys the steam from the boiler; a and c are the steam-valves, and b and d the eduction-valves. By attending to the operation in both the sections, the reader will easily understand it. It appears at first a little confused, by there seeming to be only one steam-pipe for communicating between the cylinder and the condenser; but the difficulty is cleared up, by representing both the pipes, as in fig. 4.

Fig. 5, is a longitudinal section of the boiler, representing the mode of supplying it with water, and the safety-valve and cocks. f is a small cistern, which is supplied with water from the hot-well, as represented in fig. 3; from the bottom of this cistern, a pipe goes down almost to the bottom of the boiler, where it turns up a little, to prevent the entrance of the steam which rises from the bottom. From the side of this cistern, is supported a small lever, to one end of which is fastened a wire, that carries a stone which hangs in the water of the boiler; the other end of the lever supporting also by a wire, a valve that shuts the top of the pipe that goes down from the cistern. Now, supposing the stone just at the surface of the water, and balanced by a weight at the opposite end of the lever; it is evident, that by the laws of hydrostatics, already explained, a certain part of the weight of the stone will be supported by the water, so long as it continues immersed in it; but if a part of the water evaporate by boiling, a proportional part of the stone will be above the water, consequently the stone will bear more upon the lever and raise the weight at the other end; but in raising that weight, it also opens the valve in the small cistern, and admits water until it stand at the same height in the boiler as before, and then the valve and the stone being again in equilibrio, the valve remains shut until a

new quantity is evaporated. By this means the supply of water is very gradual, however, and not by fits and starts, as here described for the sake of illustration.

It is found by experience, to be a much better method than a ball-cock, and the regular supplying of the boiler with water is of the first importance. As a check upon this, and to know perfectly the height of the water in the boiler, there are two cocks, g and h, one of which reaches nearly to the surface of the water when at its proper height, and the other enters a little below the surface.

It is evident, that if the water be at the just height, and you open g, steam will issue; and if h be opened, water will be driven out by the pressure of the steam. But if water come out from g, then the water must be too high in the boiler; and if steam issue from h, then the water is too low. By this means, it is easy to know at all times the exact height of the water in the boiler.

i is a safety-valve, to prevent the bursting of the boiler by the steam growing too strong; k is the pipe which conveys the steam to the engine.

Fig. 6 is Mr. Cartwright's steam-engine, the construction of which evinces much ingenuity. a is the cylinder, which is supplied with steam from the boiler through the pipe b; c is the piston in the act of going up; d is the pipe that conducts the steam into the condenser e, *which consists of two cylinders, one within the other, leaving a small space between them, into which the steam is admitted;* while the inner cylinder is filled with cold water, and also the external cylinder surrounded by the same; so that, by this means, a very large surface of steam is exposed, though no water is suffered to come into actual contact with it.

To the bottom of the piston c, is attached a rod, with another piston e, working in the pipe d. When the pis-

ton e arrives at the bottom of the cylinder, a valve which is in the piston, is opened by its pressing against the bottom, and opens a communication with the condenser, whilst the spring k, fixed to the rod of the piston, shuts the valve which admits the steam from the boiler. The steam, therefore, being thus condensed, runs into the lower pipe f. The piston e, arriving at the bottom of the pipe in which it works at the same time with c, presses upon the condensed water, shuts the valve f, and forces the water up the pipe g, into the box h. The air which is disengaged from the water, rises to the top of the box, and, by its elasticity, forces the water through the pipe i, which carries it back again into the boiler. When the air accumulates in the box to such a degree as to depress the water, the ball-cock falls with it, and opens a valve in the top of the box, which suffers some of the air to escape.

When all the steam is condensed, the motion of the fly attached to the machine brings the piston up again, its valve now remaining shut by its weight. On arriving at the top, it presses up the steam-valve, which admits the steam from the boiler to force it down as before.

l and m are two cranks, upon whose axis are two equal wheels working in each other, for the purpose of converting the perpendicular motion of the piston-rod into a rotatory motion, for working the machinery attached to it.

But the most valuable part of this engine is in the construction of the piston, which Mr. Cartwright made wholly of metal, and so as by means of springs, to fit the cylinder very exactly. This not only saves the expence and trouble of packing, which they are obliged frequently to renew in all other engines, but also saves a great deal of steam, on account of the more accurate fitting of the piston.

As it is evident, from its construction, that the whole of the steam is brought back again into the boiler, it affords the means of employing ardent spirit instead of water, and thus saving a great deal of fuel.

This machine seems to be peculiarly applicable to purposes requiring only a small power, as it is not expensive, and occupies little room.

It would far exceed the limits of this work, to enter into an examination of all the steam-engines invented by different persons. It is sufficient to mention, that no engine of this kind has been found, upon careful trial, to be superior to those of Mr. Watt.

From this brief description of the steam engine, the reader will be enabled to perceive the nature, and appreciate the value, of Mr. Watt's improvements. It had hitherto been the practice to condense the steam in the cylinder itself, by the injection of cold water; but the water which is injected acquires a considerable degree of heat from the cylinder and being placed in air highly rarefied, part of it is converted into steam, which resists the piston, and diminishes the power of the engine. When the steam is next admitted, part of it is converted into water by coming in contact with the cylinder, which is of a lower temperature than the steam, in consequence of the destruction of its heat by the injection-water. By condensing the steam, therefore, in the cylinder itself, the resistance to the piston is increased by a partial reproduction of this elastic vapour, and the impelling power is diminished by a partial destruction of the steam which is next admitted. Both these inconveniences Mr. Watt has in a great measure avoided, by using a condenser separate from the cylinder, and encircled with cold water; and by surrounding the cylinder with a wooden case, and interposing light wood-ashes in order to prevent its heat from being abstracted by the ambient air.

The greatest of Mr. Watt's improvements consists in his employing the steam both to elevate and depress the piston. In the engines of Newcomen and Beighton, the steam was not the impelling power: it was used merely for producing a vacuum below the piston, which was forced down by the pressure of the atmosphere, and elevated by the counterweight at the farther extremity of the great beam. The cylinder, therefore, was exposed to the external air at every descent of the piston, and a considerable portion of its heat being thus abstracted, a corresponding quantity of steam was of consequence destroyed. In Mr. Watt's engines, however, the external air is excluded by a metal plate at the top of the cylinder, which has a hole in it for admitting the piston-rod; and the piston itself is raised and depressed merely by the force of steam.

When these improvements are adopted, and the engine is constructed in the most perfect manner, there is not above $\frac{1}{4}$ part of the steam consumed in heating the apparatus; and, therefore, it is impossible that the engine can be rendered $\frac{1}{4}$ more powerful than it is at present. It would be very desirable, however, that the force of the piston could be properly communicated to the machinery without the intervention of the great beam. This, indeed, has been attempted by Mr. Watt, who has employed the piston-rod itself to drive the machinery; and Mr. Cartwright has, in his engine, converted the perpendicular motion of the piston into a rotatory motion, by means of two cranks fixed to the axis of two equal wheels which work in each other. Notwithstanding the simplicity of these methods, none of them have come into general use; and Mr. Watt still prefers the invention of the great beam, which is generally made of hard oak, with its heart taken out, in order to prevent it from warping. A considerable quantity of power, however, is wasted by dragging,

at every stroke of the piston, such a mass of matter from a state of rest to a state of motion, and then from a state of motion to a state of rest. To prevent this loss of power, a light frame of carpentry has been employed by several engineers, instead of the solid beam; but after being used for some time, the wood was generally cut by the iron bolts, and the frame itself was often instantaneously destroyed. In some of the engines lately constructed by Mr. Watt, he has formed the great beam of cast iron, and while he has thus added to its durability, he has at the same time diminished its weight and increased the power of his engine."

(To be continued.)

POLITICAL ECONOMY.

The following dissertation by Dr. E. Bollman is too good to be broken into parts: I publish it therefore together. If any of my readers are displeased with discussions on this subject, I am sorry for it. I shall hardly be shaken in my opinion, that I can insert no subject of a miscellaneous nature so important. T. C.

VINDICATION OF FOREIGN COMMERCE.

Dear Sir,

Agreeable to your permission, and, in discharge of the engagement which I have in some measure contracted with your readers, in consequence of the publicity you were pleased to give to my letter of the 16th of June, I am going to communicate to you a few remarks in vindication of foreign commerce. I shall endeavour to state them, with as much brevity, as the subject will admit of, without becoming obscure.

In all disquisitions on topics of political economy, we should constantly keep in mind, as the standard, by a reference to which the soundness of every proposition, or maxim, is to be *tested*, the probable effects of such proposition, or maxim, when put in practice, on the productiveness of labour.

The *real tacit aim* of all national exertions, so far as they consist in the sum general of individual efforts—; and the aim, to which all measures of government, with regard to national industry, ought ultimately, and unequivocally to tend, is, THE ATTAINMENT OF THE GREATEST RESULTS, AT THE LEAST POSSIBLE EXPENCE.

Whenever this point has been accomplished, a limited number of inhabitants, in any given country, will exist in the greatest state of prosperity, and wealth, of which, with their soil, their moral and physical qualifications, they are susceptible; OR, the largest possible number will be supported by the same country, in a state—exempt at least from wretchedness.

Since misery limits population, both these tests of the good economical organisation of a country, are, in fact, the same. The government which should have caused, either a truly living, not starving, and languishing population, to attain its maximum—or a limited population to enjoy the greatest share of affluence—would have reached perfection in the eye of the political economist. No government can do more.

If, therefore, the respective value of the different kinds of commerce, and the true policy of governments, with regard to commerce, are under consideration, we must refer to the same rule, the decision of the abstract question.

And, with the abstract question, examined on theoretical grounds, I shall occupy myself in the first instance. Not from any particular predilection for this mode of investigation, but from a conviction, that we are, generally speaking, less liable to err, by reasoning closely, from correct principles, than by appealing at once to a mass of facts, always difficult to *collect correctly*, and extremely difficult *correctly to understand*.

All commerce arisies from division of labour. If every family, by their own industry, could provide for the gratification of all their wants, there would be no need for exchanges. Nothing would be sold, or bought. But experience has taught mankind that their condition improves by their working for each other. The greatest degree of civilization, and prosperity, *implies mutual dependence*. The individual who should attempt to realize a strict independence, would soon, like his prototype of old, become dirty, sulky, churlish, gross. The perfectability of human nature is only developed in the social state; and from this first glance of the

subject, we are already led to presume that a nation, when trying to withdraw from the great society of nations, and to suffice to herself, assumes a situation, probably not the most favourable for the attainment of either, civilization, or prosperity.

In order to reason with aocuracy, we should distinguish in Commodities *four* descriptions of value.

The *intrinsic*, or philosophic value, which is determined by usefulness. In this respect iron and grain are commodities of infinite value. The diamond would be destitute of any, if it did not cut glass.

The *Labour-value*—which is derived from the quantum of work required, to bring a commodity into existence. Some highly finished productions of the arts exceed in this species of value all others, though their market price is often very low. The celebrated Portland-vase, according to the opinion of *Wedgewood*, must have consumed the unabated industry of a whole life, and perhaps of more lives than one.*

The *commercial-value*—which is the value of a commodity in exchange, for the circulating medium of commerce. This value should be always understood, when value is simply mentioned. It may be considered as the only *practical* value; and it is solely regulated by the supply and demand in the market, as well of the commodity exchanged, as of the circulating medium, by means of which the exchange is effected.

Commodities finally have a fourth description of value, which has not, to my knowledge, been distinctly noticed by any of the writers on political economy, and which, yet is of importance. I mean their *relative value*, with regard to those who actually have, or seek possession. It depends entirely on their *habits*, *circumstances*, and *feelings*. Of course it varies ad infinitum.

The great, and constantly changing difference in the *relative value* of commodities is the cause, and the very *simple cause*, of all existing commerce, to account for which, the luminaries of our science have singularly ransacked their brains; some, like ADAM SMITH,† seeking for its origin in a peculiar propensity of mankind to truck, and barter; in a sort of commercial instinct; others, in certain prevailing vices of the mind.

* Darwin's Botanic Garden. Part I. Canto II. Note xxii.

† Wealth of Nations. Vol. I. Book I. Chap. 2.

All that lives is stimulated by one universal passion—the desire to experience, to multiply, and to prolong, agreeable sensations. Man in particular, constantly seeks to improve his condition. This passion accounts for the existence of commerce, as for the existence of every other social phenomenon, whether beneficial, or destructive.

The commercial value of a commodity may be considered as *fixed*, at every given place, and period. Every article, if it sell at all, has its price. But the differences of relative value are *endless.*

If the price of a good watch, for instance, be a hundred dollars, and I purchase one for that price, it is obvious that I attach myself a greater importance to the possession of the watch, and the seller to that of the money; otherwise the transaction would not take place. On the other hand, it must take place, as soon as we meet, and come to a mutual explanation, since he feels less anxious to retain the watch, which I covet, than to become the owner of my hundred dollars, which I am willing to part with.

A man, returning from a long journey, and wishing to enjoy repose at home, may no longer have occasion for his horse. His neighbour, perhaps, is just preparing for a journey, and tries to find a horse, on which he can depend. If both happen to see each other, and discover how they stand mutually affected, the one will necessarily part with his horse, the other with his money, without either being impelled by any peculiar trading instinct; and both will be the better for having done so.

The difference of the relative value of commodities, therefore, or, in other words, the different degrees of consequence, attached by various individuals to their possession, is the prompter to all commercial intercourse. The thing acquired, is always preferred by the receiver, to the thing parted with in exchange; and *both parties to the transaction generally are gainers.*

It is further obvious, that the amount of their respective gains, is in exact proportion to the degree of difference in the relative value of the things exchanged.

To a manufacturer, the relative value of the commodities he brings to market, is simply equal to the expence incurred for procuring the raw material, the quantum of labour bestowed on it, and the interest of the capital employed. These items make up what the articles *cost* him; and as he made them for sale, no particular importance can be attached, by him, to their possession. If their relative value with the consumers is very great, he will, of

course, be able to obtain for them an *excellent* price. The better the price, which he is able to obtain, the greater will be his advantage. For either, less labour will be sufficient to provide for his wants, if these be circumscribed; or, the unabated, usual exertions, will the more surely, and rapidly, procure him wealth.

Thus we see, that the profits of mercantile transactions arise from the difference of the relative value of the commodities exchanged; among which we must not forget to include the circulating medium itself.

Whoever, therefore, produces any commodity, or causes it to be produced by the labour of others, or acquires the products of labour for money, with a view to dispose of them again, must be anxious to exchange them with those, with whom their relative value is the highest. The better he succeeds in this, the more will his exertions, generally speaking, be beneficial to himself, and to the state.

We have now to ask, in what situation the differences of relative value are likely to be greatest,—Whether when the members of a community trade only among themselves, or, when they exchange their productions with foreign nations?

But, diversity of relative value, arises from diversity of taste, habits, talents, skill; from peculiarities of the soil occupied; from conveniences of locality; from the nature, and quantity, of spontaneous productions at hand; from the difference of climate, of government, of the state of civilization, &c. &c.—These must exhibit stronger contrasts between distant nations, than between individuals of the same political family. Therefore *foreign commerce*, considered abstractly, that is, barely in reference to gain, *must*, *unquestionably*, *be more* beneficial than domestic commerce.*

I shall shew more fully in what the advantages of foreign commerce *chiefly* consist; and what a country sacrifices by relinquishing, or neglecting, the intercourse with distant nations.†

* Patterns and commodities, are more frequently new, abroad, than at home, and novelty always induces an increased relative value; but novelty in commerce is momentary only; and accidental: for so soon as a new article is found to fetch an extraordinary price, the market becomes always stocked, generally glutted with it. Foreign commerce therefore, reasoning *in the abstract*, has no permanent beneficial qualification over home trade. When we recur to matter of fact, the argument falls at once to the ground: for whenever foreign becomes sensibly more beneficial than home trade, it draws to itself capital, that brings on the usual level. T. C.

† The question is not, whether foreign commerce ought to be relinquished or neglected, but whether the citizens who pursue it, have a right to protec-

Foreign commerce is beneficial

1. *Because it brings into operation the advantages which may be derived from the different value of the precious metals, in different countries.*

The precious metals, now the general medium of circulation in the civilized world, may be considered, as possessing a fixed value, in the *same country*, at the *same period*, which is solely regulated by the proportion of their supply, to the exigencies of the public. But their value is by no means the same in all countries. In one, money may be scarce, while it abounds in another. The home-value of money, at each time, is settled; its *relative national value*, at the same time, is various. This is *one* cause of the difference of prices of commodities in different countries; a difference giving birth to favourable exchanges,* renouncing the benefits of which will be lost to a nation renouncing foreign trade

The precious metals abound in Mexico, whilst our manufacturers, and mechanics, excell in skill and knowledge, those of that country. Even our flour, so readily transported, is more within reach of the people at Vera Cruz, than their own, which descends to them, on the back of mules, from the plains producing it, six thousand feet above their level. † Our cabinet ware, our saddlery, our flour, and many other commodities, might, of course be favourably exchanged for silver at that place. With this silver we might procure East India muslins, teas, nankeens, and china—very de-

tion at great distances from the national territory—at an expence which no reasonable calculation of commercial gain can ever repay—and at the perpetual hazard of war, induced by commercial monopoly, commercial jealousy, and commercial fraud. Especially, as these have notoriously proved during a century and a half, the most sure and productive causes of modern warfare. It is not pretended by any person whatever, so far as I know, that foreign commerce should be either abandoned or neglected, while it can be safely, and productively pursued—without involving the consumers at home, in the expence and deprivation attendant upon commercial hostilities, to protect the speculation, and ensure the profits of the merchants abroad. T. C.

* The commerce depending upon fluctuations in the value of bullion in Europe (*even* since the depreciation of paper currency in England) is so trifling as to be perfectly insignificant in a national point of view. The course of exchange depends, not on the relative values of bullion, which influence it but in a slight degree; it depends on the right of one nation to draw on another for the balance of mercantile transactions. T. C.

† Alexander de Humbold, Political Essay, on the kingdom of New Spain.

sirable commodities, the enjoyment of which we must forego,* if we stay at home.

2. *Because it brings into full, and extensive operation, productive of wealth—all the advantages peculiar to a country, physical, as well as intellectual and moral.*

Without foreign trade, every natural, or attained advantage of a country, however great, or peculiar, is only improvable commensurately with the consuming capacity of its inhabitants.

If Pennsylvania, for instance, contained an abundance of clay, flint, and other materials for pottery, superior in quality to any other in the world, the Pennsylvania pottery would not, on that account, if never exported, command any extraordinary price at home. *Nothing can procure an advantage in exchange that is common to all.* From the supposed abundance of the good material, and the necessary effects of competition, the pottery would be brought to market at the lowest price, at which it could be afforded, so as to yield a living to those engaged in the business. But, if the sales of Pennsylvania pottery, from the preference given to the ware, extended to all the civilized portions of the earth, it might so happen that the supply could not keep pace, with a demand so vast, which would cause an increase of price, and a greater proportionate gain.† Or, if the supply kept pace with the demand, and the prices remained unaltered—still thousands of potters would owe a comfortable subsistence to the clay, instead of a few hundred only, whom the business at most could have supported without exportation.

Nor would other trades be deserted, on account of the great

* Not at all: the nations who have them, will bring them to us, if we have wherewithal to pay for them. Are not we ourselves so anxious to export these articles, that our merchants complain incessantly of Great Britain who will not permit us to sell them in the West Indies for Rum and Sugar, in Holland for Gin, in Italy for Anchovies and Olives, and so on? T. C.

† All these supposed advantages of foreign commerce, proceed upon the supposition, not of reasonable, but unreasonable gain: a circumstance that always and inevitably, works its own destruction. Or, of an over-populated country, that calls for every possible exertion and every source of employment to keep its inhabitants from starving. This may be the case in England, but cannot be so here for a long time to come. Nor is it true, that what is common to all, can procure no advantage in exchange. Labour judiciously and industriously bestowed, can give exchangeable value to any material however common, in the home as well as in the foreign trade. Connecticut can sell her tubs, her onions, her coffins, even in the United States: so can Rhode Island her straw bonnets, her cotton twist, her home made woollen, &c. T. C.

numbers required for the potteries. *Men appear as they are wanted.* And all the potter's needs must eat, and be lodged, and clothed.

Besides potters, what a large number of other people—carriers, packers, dray-men, brokers, merchants, underwriters, shipbuilders—what a host of artists, and tradesmen, concerned in furnishing the materials for ships, and in equipping them—all would more or less, derive support and affluence from the clay.* For, if our pottery, in the supposed case, were exported in our own vessels, the foreign consumer, besides the labour of the potters, and the value of the materials, would have to pay the merchant's commission, the merchant's profit, small charges, insurance, and freight—which items are included in the price the exported article must bring abroad. If it did not bring this price, the exportation would discontinue.

Further—in consequence of all this industry which the clay puts in motion—what a mass of additional livers, to consume, and give value, to the produce of the farmer.

We have no such clay in Pennsylvania. But, does the same reasoning not apply to every article which we are in the habit of exporting; to our flour, to our pork, to our flax seed? Do they not all bring abroad their cost, and the enumerated charges? Does it not strictly apply to the cottons, the tobacco, the tar and turpentine of the south? to the fish, and the potash of the north?†

* All this is very true; but is there no method of employing the same number of people and the same quantity of capital in the home trade? The case put, of a Potter, is a very unfortunate one; for so far from wanting an export trade for our pottery, we do not supply the 1000th part of our own consumption in pottery, except of the very coarsest and least valuable kind. When the time shall arrive, if it ever do, that no employment for our people or our capital remains at home, then it may be worth discussion whether we may not as well encourage employment from abroad by direct means, and at any hazard. At that period of time, and not sooner, will the argument in favour of the direct encouragement of foreign commerce really become a subject of important discussion. T. C.

† I see no difficulty in manufacturing a great part of our flax seed into linen—of our cotton into cloathing, and carpets, and sail cloth, and bagging—our potash into soap and glass, and employ it in bleaching and dying. If we did so, our flour and our pork would not spoil upon our hands. But in this, as in all other particulars, the question is, can you manufacture it, or export it, to the greatest advantage? If you can export it to more advantage, do so; but do not tax us, the consumers, with the expence and inconvenience of a war to defend your gains in the export trade, when no such expence or inconveni-

—We had always plenty to eat. If all the cotton and tobacco lands are turned into wheat fields, the flour must necessarily spoil on our hands. Nor could we possibly manufacture up all the cottons, which we exported, to the amount of nine millions of dollars per annum, were they within our reach; nor chew and smoke all the tobacco, cook all the fish, turn all our potash into soap and glass, or find possibly any use whatever for the tar, and turpentine of our forests.

Let it not be imagined that we loose nothing, because we do not yet seem to suffer. We slowly consume our past accumulations, while we throw on posterity the cost of our folly. To stop in the career of prosperity, is to retrograde: and a corrected policy, with redoubled exertions, will, for a long time, strive in vain, to attain that eminence of national wealth and power, which, but for our want of wisdom, we might have occupied.

There are many productions with us, as in most other countries, which, where they grow, or are found, have little or no value, but which may be exchanged to great advantage abroad.—No body here uses ginseng, but it commands in China commodities, the possession of which is desirable. Our oak-bark is of little use to us, and could hardly be consumed even if all the nation were to dress in yellow*; in England it was exchangeable for objects we want. The trimmings of our sheet-iron accumulate in large heaps round our rolling-mills; the Chinese gave us silks for them. The leeches of the ponds round our city—to the amount of 15 to 20,000 per annum, were exported to the West Indies, and made several thousand dollars circulate in this neighbourhood. How is the community to be indemnified for their loss, unless indeed you were to imagine that they ought to be let loose on the redundant blood of our own citizens, to

ence need be incurred by or on account of any citizen employed in the home trade. Go abroad: at your own risk: if the profits will pay the insurance, go on: if not, employ yourself and your capital at home. There are manufactures to establish without number; a population to be supplied incessantly calling for your articles; lands to cultivate without limits; employment for money and for people, that centuries will not satisfy. T. C.

* It is granted, that the nation gains by exporting articles that yield a profit abroad and none at home. But let us not set up a man of straw, and exult in the victory of demolishing him. The question is not, shall we export useless articles, or keep them at home to spoil and waste—the question is, do we pay too much or not, for the profit they bring? Under what circumstances and conditions can the export be *prudently* made? T. C.

make them eat more, to replace the waste, and thus to stimulate agricultural industry by an increased demand for food!

There have been exported from new Spain upwards of two thousand millions of silver dollars, since the first discovery of that country, and agriculture flourishes most in the vicinity of the mines.* Of what use to the people would have been all this metallic treasure if not exported?—Cochenille, Jesuits-bark, Vanilla, the most valuable spices, are the spontaneous productions of the countries whence we receive them. A considerable commerce is carried on in Swallow nests from Cochin China to China.†

If some nation had as great a fancy for dried oak leaves as we have for tea,‡ and would give us commodities, on which we set value, in return for them—will any one be so mad as to say, that we should gain nothing by their sale abroad? Would not millions of people derive support and comfort from gathering, and preparing them for the market? The country thickly settled, and other things remaining unchanged, must they not starve, and perish, if their exportation were to cease?§

* Alexander de Humbold, in the work mentioned before.

† Barrow's Travels to China.

‡ Do the Chinese need a foreign trade of merchant ships protected by ships of war, to sell their tea? Can any example be more in point, to shew, that if you possess commodities of value to give in exchange, the merchants of other countries will let you want for nothing? Still I am no advocate for imitating the Chinese. Shew me that your foreign trade, yields a reasonable profit, after all the expences of the merchant are paid, and all the expences of the *nation* are paid, and then I agree, it is well worth pursuing. If a merchant gain 20 per cent. on his capital, and a farmer gain 20 per cent. on his capital, the consumer not only pays the mercantile profit of 20 per cent, but for the most part of 50 per cent. more to protect the merchant's speculation. T. C.

§ I hardly know how to suggest a stronger argument against the *encouragement* of foreign commerce than this suggestion of Dr. Bollman, in favour of it. If manufacturers at home are made absolutely dependant for subsistence, on customers abroad, whom accident, caprice, poverty, competition, war, may strike off—then shall we frequently behold, as of late years in England, famine pervading the land, and thinning the ranks of that class of the community, who might be made the main strength of the nation. In Great Britain, within these six years, at least half a million of wretched manufacturers would have starved, if war had not invited them to the wretched alternative she holds out. The war itself, in which that nation has been involved, has not produced altogether so much evil in other respects, as in making the poor manufacturers feel so cruelly, the lot of those whose bread depends upon foreign trade. T. C.

If all the West-India islands belonged to one sovereign, and he should, miraculously, happen to be a wise man—can it be for one moment conceived that he would attempt to increase his power, and promote the prosperity, and wealth of his subjects by causing them to raise sugar, coffee, and the other productions, peculiar to those climates, only in sufficient quantity for their own consumption, and to procure sparingly, imperfectly, at a vast expence of labour and time, or totally to forego those enjoyments, and that wealth, which attention to the productions most favoured by their tropical situation, and their unrestrained exportation would procure to them in abundance, and with ease?*

The condition of France cannot be thought to have improved, because she is obliged, in compliance with Napoleon's mandates, to extort from a crop of five acres cultivated in beets, as much indifferent sugar as the wheat of one acre would procure from abroad of an excellent quality.†

We have hardly, in our wealthy country, a sufficient quantity of rags to supply us with paper. But Italy could not consume the paper which her inexhaustible rags, were she to work them up herself, would bring into existence. She exchanges them for West-India produce and hard ware. She does the same with the alum, the sulphur, the puzzolana‡ of her burning mountains.

All my readers probably know, that the current of opinion among the literati of England, and especially of the reviewers, such as the Edinburgh, and the Monthly, is opposed to the prevailing madness for foreign commerce. The Edinburgh Review moreover, conducted with much ability, is generally in opposition to the present politics of the British government. To counteract the effect of the disquisitions in that review, the Quarterly Review was set on foot, as a general defence of the measures of government in church and state. Yet even the Quarterly Review, is struck with the manifold misery of which a dependance on foreign commerce is at one time or other the inevitable cause. I will put in a note to the end of this paper, the extract to which I allude.

* No. I am a fixt advocate for raising every thing that can be sold or bartered with profit. I greatly approve of unrestrained exportation. Let the merchant carry what he pleases, where he pleases, *at his own risk*. If his trade be hazardous, it is his own affair: it is his duty to sit down and count the cost: he has no claim upon the nation to take the hazard upon itself. T. C.

† But sugar sells in France for 15 sous. The dollar passes for 108 sous. That is about 7lbs. for a dollar. T. C.

‡ The Puzzolana or Terras, is hardly now an article of export: its use is superceded by the admixture of Smithy-slack and the cheap oxyds of iron with mortar. T. C.

Shall those, who are thus supported, be abandoned to misery, that the anticommercial system may flourish?

The agriculture of Sweden is inadequate to the maintainance of her people;—shall part of them be driven off, because they cannot learn to digest copper and iron?—must the island of Madeira be evacuated, because no longer permitted to send abroad her forty thousand pipes of wine?—must Geneva become a village, because no longer allowed to supply the world with watches?*

Due efforts will be attended with the greatest success, when bestowed on that branch of industry for which the country from its physical condition is best calculated. The more this can be exclusively followed, the greater will be the wealth acquired. It must therefore be the interest of every nation to extend the markets for her staple commodity to the most distant regions.

In the same manner, intellectual and moral acquirements will become productive of greater national benefits, when displayed on the theatre of the world, than confined to the narrow sphere of domestic concerns. The probity and fairness in dealing, for which it is said, that British manufacturers are distinguished, promises to them no exclusive advantage at home, but insures a preference among foreign customers. Confidence abroad, and the command of foreign funds, are happy results of an impartial execution of the laws. Public faith makes public credit an exportable commodity; and insures to younger nations, a participation of the benefits arising from the large capitals of the old. Banking is not less lucrative and eligible when transacted among nations, than as a business among individuals.—Skill, credit, character, ingenuity, activity, prudence, which lead to fortune in private pursuits, must yield still greater results when nationally pre-eminent in extensive commercial concerns. Correct, and minute information of the wants of mankind in every spot, is of itself, a most powerful engine of wealth, but it can neither be acquired, nor rendered valuable, without a foreign trade.

* It is a great misfortune when the existence of a people depends upon the sale of articles, which their customers can dispense with whenever they please and without inconvenience; and in which, other nations may so easily become competitors. This I have already averted to. T. C.

3. *This trade is beneficial because it contributes materially to carry the division of labour, and the introduction of labour-supplying machinery to their greatest extent.**

The object of all labour being the gaining of a subsistence, it cannot be expected that any man should devote himself, exclusively, to any particular branch of industry, unless the demand for the article produced, or raised, be sufficient to insure him a remuneration adequate to his exertions.

In an isolated settlement, consisting of eight or ten families, no one could be a miller, because the trifling demand for flour could not afford him employment, and support. For the same reason such a settlement could not support a shoemaker. The man who should grind the grain, or make the shoes for his neighbours, would at the same time be obliged to follow some other profession, or employ part of his time in farming. Should the growth of the settlement at last allow a man to devote himself exclusively to the working in leather, still he would be obliged to make men's shoes, women's shoes, children's shoes, and boots. In a still more populous community, all those subdivisions of shoemakers would become distinct branches; till finally some hands would make only a particular description of men's, others of women's and children's shoes—even the binding of them would become a distinct trade, and it is at this period that the public generally, would be supplied with the best shoes, of every description, at the lowest prices.

The same observations apply to every other trade, and pursuit. They also apply to the introduction of machinery.

Most machines perform but one operation. In order to warrant the investment of capital in the construction, or acquisition, of a machine, it is necessary that the performance of that operation should recur sufficiently often to enable the machine to earn the interest of the money it cost, and a profit besides.—A farmer, who cultivates a few acres only, will not think of having a thrashing machine.—The consumption of a few plates of sheet iron, of a few nailrods, will not warrant the construction of a rolling and slitting mill.

* Not more from an encreased demand abroad, than from an encreased demand at home. In point of fact, the best finished and more costly manufactures—those that incite chiefly to improvements in machinery, are seldom exported. The best woollens, best cottons, the best pottery, the most expensive hardware of the British market, are *never* seen in this country, which is Britain's best customer. T. C.

The essential condition of a great division of labour, of the general use of machines, and of all the most valuable improvements of civilized society, is enlarged activity, and an extensive scale of operation.—There must be much travelling, and much conveyance of property, before we can think of stage coaches, turnpikes, and steam-boats. There must be a vast deal of conveyance of property, before there be question of canals, and rail roads. —*The aggregate industry of a country becomes productive o aggregate benefits, which are large, which are immense, precisely in proportion as the magnitude of the total exertions admits of the performance of every single operation in the larger way.*

Would the industry of the city, and county, of Philadelphia be what it is, if no intercourse existed beyond the county line? Would the state of Pennsylvania be what she is, if no commercial intercourse existed with the adjoining, and distant states? Would this trade, now so beneficial to her, be less so, other circumstances remaining the same, if the erection of separate governments in New England, in the Carolinas, or in Kentucky, transformed it, from a domestic, into a foreign trade? Or can it be imagined that a commercial intercourse with the island of Cuba, admitted to be beneficial if it could be called home trade, should cease to be so, merely because that island forms no part of our political union?*

But, if industry, from the reasons stated, becomes productive of wealth, in proportion as the different branches of it can be pursued *largely*, foreign trade must be productive of wealth, because it swells the number of consumers, which put every branch in motion, with additional millions, all over the world.

4. *Foreign trade is beneficial, because it is the surest means of preventing, both want† and waste.*

From the necessary effects of competition the prices of every species of produce of the growth of a country, which has no fo-

* It cannot only be imagined, but demonstrated. If the political union of the United States, were reversed, so that the commerce between Philadelphia and New-Orleans, which is now home trade, should become foreign trade, the value would be lessened by the change of laws, by political jealousies, political restrictions, and the chance of political hostilities induced by mercantile squabbles: none of which hazards exist at present. T. C.

† How far it prevents *want*, let the present state of England determine; one eighth of whose population are now paupers, *notwithstanding the war*, which has found employment for so many. The poor's rates of that country amount to six millions sterling, and the charitable contributions toward the support of the poor, to about one million more. T. C.

reign trade, will generally come down to their lowest rates—that is, to the rates at which those, who raise it are just compensated for their labour, and the investment of their capital. As soon as the price of any species of produce falls below this rate, less of it will be raised, till it has returned to the usual standard.

Since, therefore, consumption naturally limits production, it is obvious that *want* must take place whenever, from an untoward season, or any other cause, the usual crops fall considerably short. Consequently we see that all countries, which have little or no foreign trade, are occasionally subject to famine, with its attending train of disease, and horror. An exporting, agricultural country, is exempt from this calamity. Raising, generally, more than is wanted at home, there will, even in years of scarcity, still be enough for domestic consumption.* *Le superflu*, as Say expresses it, *est le gage du necessaire !*†

An exporting manufacturing country has always extensive connections ready formed, and, with the means of purchasing, easily supplies itself from abroad on any extraordinary emergencies.

A country in which both, agriculture and manufactures, are limited by domestic consumption, must be necessarily within the reach of the calamities mentioned ; and the more so, the less its territory is extensive, and the less are various its productions, and climate.‡

We have already seen that a country, deprived of foreign trade, cannot improve to the utmost the advantages *peculiar* to it. But, leaving any natural advantages unimproved, or improving them only partially, is a species of *waste*.

A further, and very injurious *waste*, in a country, relinquishing the benefits of foreign commerce, would result from the circumstances, that the refuse of many descriptions of manufacture, could be no longer turned to account ; nor the injurious effects on industry, arising from the constant changes in taste, and fashion,

* Let us see how this consists with matter of fact. Great Britain is an importing and exporting agricultural nation. She gives a bounty on the export of grain. She has the most extended foreign trade the world has ever seen. France has none. Yet would Great Britain, 2 or 3 years ago been without bread to eat, had not her enemy France supplied her with grain to the amount of seven millions sterling. T. C.

† I. B. Say—Traite D'Economie politique.

‡ How does this apply to the United States of America ? T. C.

and from the progress of improvement, be any longer successfully corrected.

The coarse woollen cloths of England, could not be afforded so cheap, nor made so good, as they are now made, but for the employment in that manufacture of the refuse wool of the superfine cloths. Circumscribe therefore the market for either, and both must become dearer, or worse.*

Tin shreds, and old iron hoops, would be of as little value in England, as they are here, if she did not supply with copperas nearly all the civilized world.†

The residues left in the processes, now employed for bleaching and other purposes, render many chemical preparations in England cheap, and exportable. Diminish the vent for these, and bleaching, and similar operations, will become more expensive.

The articles, out of fashion, or, turned by new improvements out of use, would become waste in England, and involve in ruin those who manufactured them, or bought them for sale, if the world were not before her, if an extensive foreign trade did not cause them to find a vent, in regions where different tastes prevail, or which are regularly somewhat behind hand in matters of fashion and civilization.‡ In consequence of this resource she is able always to consume herself, at moderate prices, what is newest, and what is best. Without it, all manufacturing operations must be carried on with much more timidity, and on a smaller scale, that is, with less profit. Improvements, and the spirit of exertion would be checked. The better article could not be brought forward, till the worse was sold off, or could only be offered at a price so high, as to compensate for the loss of the latter. The rewards of industry, and ingenuity, would become more precarious, and consumption itself would diminish, for want of the

* They are as much economized in our own country, where all refuse woollen can be worked up into home made carpets. T. C.

† I see no reason why we should not supply ourselves. It can be done to profit. T. C.

‡ I can well remember the outcries at Birmingham on account of the very convenient substitution of *covered* for metal buttons, of *strings* for shoe buckles, and buckles of the breeches knees. The Prince of Wales was petitioned to countenance buckles and buttons; and parliament I believe interfered against covered buttons. Surely this is not a benefit, but an evil resulting from the system of commercial manufacture. T. C.

stimulus to consumption, now found in the constant novelty, or the superior excellence, of the productions offered.

The utmost division of labour, therefore, unabated activity, unremitted exertions to extend improvements, enlarged ideas, and their great result—a steady progress of civilization—are only compatible with those prudential considerations that ultimately guide the conduct of individuals, in a country enjoying an extensive foreign trade. In such a one alone, that most useful description of citizens, the merchants, are able to take care that nothing, any where of value, be wasted, and that every natural or artificial advantage, be improved to the utmost.* The condition of most of those, which are deprived of this trade, is nearly stationary, all over the globe. Hungary—with her immense natural riches, the interior of Germany, Poland, Switzerland, Turkey, the beautiful regions of Africa, bordering on the Mediterranean, and China, are what they have been for centuries past,† whilst France, and particularly England, seem every thirty or forty years, to exhibit a new creation; whilst the United States, to judge from the rates of their progress since the revolution, bid fair to surpass, in time, even England herself. In both countries an extensive intercourse with the rest of the world has caused every commodity, and every production, that could be spared, or the use of which, at home, was superceded by a better commodity, and a better production, to find a good market abroad. *Nothing has been lost!* Gains have been multiplied by combined mercantile operations, between the most distant nations. Extensive information has become a productive capital. The rectitude of government, impartial administration of justice, and public credit—a source of wealth.‡ No individual riches have been hoarded, as they generally are in badly governed, or secluded countries, where thoughts and people become trifling and contracted. On the con-

* This is not the business of the merchant either in theory or in practice. It is the province of the manufacturer, whether for the home or the foreign trade. The merchant is a mere factor: he finds out markets, and purchases the goods there wanted. But he has nothing to do either with saving or improving as Dr. B. states. T. C.

† This is owing to political errors in Government—to ignorance among the people—to despotism:—not to the want of trade. What trade has France had for these twenty years past? Yet has her power or her knowledge diminished? England has monopolized till a few years back, the trade of the world: has her power permanently encreased? Assuredly not, as I think. T. C.

‡ Are not these perfectly consistent with the home trade? T. C.

trary—the constant temptation to agreeable consumption, by an infinite choice of valuable commodities; and to new accumulation, by an extensive range for enterprize, have caused them widely to circulate, and to encourage industry in all its vast ramifications.

The preceding considerations appear to me to be the principal ones, that can be urged, theoretically, in support of the great utility of foreign commerce, and, I believe, they warrant the following conclusions.

1. Commerce generally is *more beneficial*, in proportion as it is *more foreign*—that is, the less resembling each other in their situation, habits, and local circumstances, the parties are between whom it takes place.

2. Foreign commerce, whenever it arises of its own accord, is useful as a matter of course.—It is exchange of commodities. None are delivered, except in return for others, and each party must prefer those it receives to those it gives. The business could not otherwise be pursued.

3. Foreign commerce is particularly useful to countries of which the territory—is small; the climate—little diversified; the productions and commodities of which are few in number, and peculiar in kind, whilst their situation facilitates distant intercourse.—The more an empire, like that of China, is a world in itself, the less the want of foreign commerce is to be regreted.*

I shall now proceed to examine the arguments which, in your political arithmetic you have advanced against foreign commerce, and against the *commercial system* generally—which must mean, the system of an unrestrained and extensive commercial intercourse between nations, and nations.†

But, in the first place, I should wish to object to the idea of

* This applies still more specially to the United States. T. C.

† I do not object to commerce, or the foreign trade. I am no advocate for restraining it. I think the interference of government to restrain or to promote, or in any way to guide and controul the effects of individuals to gain wealth, is worse than injudicious, unless under circumstances of state necessity; where the interference is, not to promote or protect the interest of the individual, but that of the nation.

But I think foreign trade is not so productive, so beneficial, so safe, so peaceful, as the home trade. I think it does not pay for national protection in any country. T. C.

any thing like system—agricultural, or commercial—in political economy, and even to the very term, applied in the manner in which it has been used.

With regard to individuals there may exist a system of agriculture, of commerce, &c.—that is a connected body of principles, and rules, according to which the cultivation of the soil, and mercantile pursuits are to be conducted. But, what we understand by agricultural, commercial, or manufacturing system, in political economy has no existence, except with regard to governments. According to the writers on that science we should imagine that every government has to determine whether to adopt the one, or the other—whether to protect agriculture, or manufactures, or commerce. Now this seems preposterous

1. Because no country can be, exclusively, agricultural, or manufacturing, or commercial. Even if a nation were settled on a rock, and subsisted solely by commerce, they must needs have among them a number of tradesmen, and artizans ; a number of men—not merchants, equally entitled to the care of government, and to protection in their lawful pursuits; equally essential to the well-being of the community.—Governments would, generally, be wrong, in pretending to grant protection, or encouragement, to those addicted to certain pursuits more than to others.*

2. Because whatever doctrine theorists might attempt to establish, respecting the degrees of utility of the various main branches of industry—it could, obviously, not lead to any general rule, to any exclusive policy, by which governments ought to be guided, since the callings of different nations—if I may use the expression—like the callings of individuals, have been differently ordained by nature.

3. Because the sound, and only true policy, which ought universally to prevail, is to let individuals find out, what course of activity is, in the country to which they belong, the most beneficial, and afford security, and grant protection, in their lawful pursuits, indiscriminately to all.—"*laissez les faire.*"—As soon as government turns its attention to one of the systems it begins to err ! Then why create them on paper, unless it be for the pleasure, too frequently sought by the learned, of displaying their perplexing sagacity !

* This is all I contend for. Let the merchant, the manufacturer, the farmer, each carry his goods to market at his own risk. T. C.

A more singular, and I might almost say, a more improper discussion, could hardly have arisen, than that concerning the respective usefulness of agriculture, manufactures, and commerce, in a national point of view.—We do not agree, whether it be better to be a joiner, or a black-smith? a farmer, or a weaver? and is it not the same with nations as with individuals? All depends on their respective situation and faculties. Nor can it be imagined that one branch of industry should be incompatible with the other. The tradesman, who buys his grain, and his meat, does not on that account, preclude himself from cultivating a garden. The farmer, who has his linen made at home, does not therefore scruple to buy his cloth, and his hardware. Few pursue solely what they find it convenient, and useful, to pursue principally. We are called an agricultural, and commercial nation, yet, we have been, for some time past, in the habit of manufacturing a considerable proportion, perhaps nearly the half, of the several commodities we consume.

Whenever a considerable number devote themselves to one branch of industry in preference, as their main occupation, we may take it for granted that they have found it to be the most expeditious means of procuring an honourable subsistence; and that they cannot be disturbed without injury to the state.

There should, therefore, in my opinion, be no question of systems. But, since they have been brought into discussion, let us see why you are so averse to that of foreign commerce. The enquiry will throw a further, and important light on the subject.

" *Capital*, you say, with Adam Smith, *employed in the home* " *trade, is more beneficial to the country than that employed in* " *the foreign trade, or the carrying trade.*"

The inference is—that therefore the home trade ought to be pursued, the foreign, and carrying trade relinquished.*

The position is only *conditionally*, not absolutely *true*. If two adventurers from Philadelphia, the one to Lisbon, the other to Charleston, produce both *the same aggregate profits*, and put both *the same quantum of industry* in motion, no doubt the home adventure will be the most beneficial to the country, because the favourable, pecuniary and moral results, are *all our own*.

But, if the adventure to Lisbon were to put in motion as much industry at Philadelphia alone, as the adventure to Charleston puts

* I have never drawn such inference. T. C.

in motion at both ends of the voyage; and, if the profits, made by the Philadelphia merchant alone in the former, were equal to the joint profits of the Philadelphia and Charleston merchant in the latter—the position would *not be true.*—A superiority of profit or of industry put in motion, would even establish for the foreign voyage a decided claim to superior national utility.* The correctness of this observation is so obvious that it needs no proof.

Now it is well known, that the ndustry, put in motion by a voyage, other circumstances being equal, is nearly in proportion to the distance of the voyage.†—Our inland trade is carried on in boats, and waggons; our coasting trade, in small craft; the foreign trade, in vessels of a superior order, the building of one of which costs as much—that is, puts as much industry in motion, as perhaps the building of twelve, or fifteen, of the former.—But, not only the vessels are more expensive, their equipments also are more costly. Freights and insurance, consequently, amount to much heavier sums, and even the small charges will be much more numerous; so that a foreign adventure, which terminates well, often brings back a capital the double, or triple of the original cost of the outward cargo, whilst the gain of the shipper does not exceed the ordinary rate of mercantile profits.—In this respect we may say, that a barrel of flour, and every other commodity, *provided we transport it ourselves*, puts more industry in motion, in proportion as the market, we are able to find for it, is far removed.‡—If the merchant's gain is considerably greater at the same time, it follows that the country must benefit more by the foreign, than by the domestic expedition.

* That is *cæteris paribus:* all other circumstance being equal: as, that the trade to Lisbon requires no more expence of national protection, and puts in jeopardy the national tranquillity no more than the trade of Charlestown. T. C.

† I believe the direct contrary is the commonly-received, and well-founded opinion. The more distant the voyage, the less frequent the returns of capital; but the quantity of industry put in motion, does not depend upon the quantum of capital employed, but on the frequent return of it. A capital of 1000 dollars returned twice a year, puts in motion a quantity of industry equal to 2000 returned annually. T. C.

‡ I greatly doubt whether any merchant would act on this principle, and prefer a trade because it was distant. Besides, the expences of the crew are laid out abroad in great measure: and in fact it is universally true, that the more distant the voyage, the greater the risk, the less frequent the return of capital, the more is protection needed. It is also true, universally, that the industry put in motion by domestic trade is exclusively home industry; by foreign trade, foreign as well as home industry. T. C.

By these considerations, in combination with those detailed in the preceding pages, the truth of the *position* is materially weakened, if not entirely overthrown. But, were it unquestionably true, still the *inference* could not be admitted, without great limitation.

If foreign trade is less beneficial than the home trade, *and they were opposed to each other*, then, surely, the former ought to be relinquished. But, it so happens, that both are most vigorous, when pursued at the same time, and the deplorable history of the day proves but too well, that, with us in particular, the destruction of the one, is nearly tantamount to the destruction of the other.*

The same observation applies with regard to the carrying trade. The prosecution of one description of business does not necessarily presume another to be neglected. *The natural limits of the activity of a merchant are his gains.* You can confine him in no other without prejudice to the country.

——" *The capital*, you continue, *employed in the home trade*, "*circulates twice*, *or thrice*, *while a capital*, *employed in the foreign* " *trade*, *circulates but once*."—

Inference—therefore the foreign trade, less profitable, is to be abandoned.

The position, again, is not generally true.—A capital between New Orleans and the Havanna, between New Orleans and Vera Cruz, may be turned twice, and oftener, before it can once be turned between New Orleans, and Pittsburg, or Lexington. The voyages from London to the ports of the German Ocean, are not longer than those from London to Liverpool, or the north of Scotland. Exchanges of property between Ostend and the British ports opposite, will be much more rapid than those between Ostend, and the French ports in the Mediterranean. A voyage from Archangel in Russia, to Odessa in Russia, would encompass the European continent—yet this would be home trade !†

Nor does the returns of the capital sent abroad—as the reader would be led to believe from your enumeration of the many hands through which it has to pass—depend on the realized proceeds of

* I am not aware that this position admits of satisfactory proof. T. C.

† These are merely local exceptions to a general proposition, the truth of which cannot be denied. But the point is, that home trade requires no national expence to protect it—induces no national risk—produces none but home feelings, home interests, home predilections. These characters do not belong to foreign trade. These are circumstances that operate universally, whether the trade be from Archangel to Odessa, from Boston to New-Orleans, from Dover to Calais, from Gibraltar to Ceuta. T. C.

the identical property shipped. Vessels, generally, bring back a return cargo promptly, and to the country it is immaterial, whether this be the actual proceeds of the outward cargo, or a property shipped in advance of the expected proceeds, or the results of some previous adventure. A regular intercourse once established, the returns depend no longer on sales, and mostly vessels bring back a value, equal, or superior, to that taken out. Consequently, in a national point of view, the capital employed in a foreign adventure, may be considered as replaced with a profit, as soon as the voyage is terminated. Were it otherwise, if the trade continue notwithstanding, it would only prove that the country has capital to spare, which it cannot employ, to equal advantage, in any different manner.

Further—if the *position* were strictly true, still the *inference* would not stand.

The question is not, whether the more profitable home trade, is to be abandoned for the less profitable foreign trade. There can be no such question, unless there were a deficiency of capital. If this deficiency existed, the capital would, of its own accord, seek, and find, the employment most profitable. But it is not likely to exist in a country like ours, that has commodities to exchange, and circulate by means of paper; because in such a country credit is capital, and credit keeps pace with the amount of exchangeable property.

The true question is this—if the home trade puts in motion industry, to the extent, for instance, of one million of dollars, and an additional foreign trade might put in motion industry, to the amount of half a million more—whether the nation is to forego this advantage, merely because the trade would be foreign,—and I believe you will agree that the strictest logic, even from your admitted positions, would hardly warrant such a conclusion.*

* I never drew any such conclusion. An opinion has long prevailed, that foreign commerce is the great source of national wealth: the English writers until about five or six years ago, were almost unanimously of that opinion. The British ministry, have for more than sixty years past even to the present day, held up in theory, and have practically pursued the same opinion. The modern politicians of this country, particularly those who are somewhat biassed in favour of British practices and theories, strongly support the same opinion. M. Say, M. Ganilh, Dr. Bollman, are decided advocates in its favour. I have done nothing but attempted to shew that this opinion is not well founded. That foreign commerce, is insignificant in point of amount to the produce of capital and industry employed at home. That it is a productive cause of modern war. That it induces national expences for its protection, far beyond

You next advert to "*the comparative importance of the foreign* "*trade, and home trade, in point of amount.*"—You endeavour to shew, that the amount of the latter trade, even in England, whose foreign trade is now the most extensive, dwindles into insignificance, when compared with the amount of the former, which confirms you in the opinion that the foreign trade ought to be relinquished.

In order to prove the relative inferiority, in England, of foreign to domestic trade, you have recourse to the custom house documents. You shew

"That previously to the year 1794 the amount of the exports "of Great Britain have never exceeded twenty five millions of "pounds sterling per annum,"—let it be granted!

And you state "that the merchants profits cannot be estimated "at more than 12½ per cent."—I do not object to it.

"Which, on the 25 millions exported from Great Britain, and "3½ millions, exported from Ireland, makes 12½ per cent on 28½ "millions, or, about 3½ millions sterling."—The calculation is correct!

From which you conclude "That the foreign trade of Great "Britain and Ireland, at one of the most prosperous periods of "British commerce, was not worth to the nation more than three "millions and a half of pounds sterling,"—a conclusion to which I can by no means agree.

You have, evidently, fallen into an error, so frequently committed by political writers, and which I have already noticed in another place—*the error of confounding the national gain, with the mercantile profits.*

They are so very different, that the national gains are often large, in proportion as the profits of the merchant are small. Nay *the nation often gains, and immensely too, while the merchant actually incurs loss.*

Suppose us at peace, trade open, flour at eight dollars per barrel, and an account arriving of a failure of crops in England, in consequence of incessant rains during the month of August. Flour rises to $12 per barrel—200,000 barrels are bought by our merchants, from our millers, at that price; they are exported in our own vessels. They cost, delivered in England, in consequence

its value. But *if it can* be profitably pursued without requiring national protection by means of a navy fit to enter into competition with the great naval powers of Europe, *then* it becomes worth pursuing. T. C.

of the accession to the first cost, of small charges, freight, and insurance, $ 15. They sell so as to neat only $ 14 per barrel. What is the result of this foreign trade?

The merchants lose one dollar per barrel, or $ 200,000.

But the nation gains

1. The difference between $ 8 and $ 12 per bll. is on 200,000 barrels—800,000

2. The expences thereon	$ 600,000	
Less the merchant's loss	200,000	
		400,000
Total neat national gain,		$1,200,000*

To which, in fairness, we ought to add, all the good springing from the influx of so much additional stimulus to industry. Yet, according to your mode of estimating the results of mercantile operations, the nation would be, by $ 200,000 the poorer for having meddled with this foreign speculation.

The view of the subject, which I have just given, and the correctness of which will hardly be questioned, accounts for the phenomenon, that so often communities *thrive*, though merchants *fail*. The competition among these raises the prices of the native, or manufactured productions of a country, and though, in consequence of it, the more sanguine, and enterprising among them, will frequently ruin themselves, yet they will be seldom so egregiously mistaken in their calculations, that the country should not benefit by their labours. We also see, why banks, and similar institutions, which give facilities of trade to men of moderate means, contribute so much to the wealth of a country. In their absence much less business would be done. A few capitalists would keep the prices of domestic produce down, and maintain at high rates the prices of commodities imported from abroad. They would gain much in doing little; that is, they would cause the community at large to work for less, and amass colossal fortunes at the expence of the labouring classes.

Such is the case in South America, in Old Spain, in France.

* It is hazardous to prove too much. If I employ an outfit of 20,000 dollars, doubtless the tradesmen I employ will have their reasonable profit; all this profit is national gain; but if in the upshot of the transaction, I lose 1000 dollars instead of gaining 1000 dollars, is not the part of the national capital under my care diminished by that sum? can this be called a national gain?

T. C.

There, merchants seldom break, but squalid poverty is the lot of the people.*

Many more important deductions might be drawn, from the simple discrimination between *national gains*, and the *gains of the merchant*, but they would lead me too far. Let me apply it to the point under consideration.

Foreign trade is not carrying trade. If British merchants employed a capital of 28½ millions of pounds sterling, in effecting exchanges of property, in vessels not their own, between America, for instance, and the East Indies, and cleared by those operations twelve and an half per cent. on the amount invested—then perhaps the 3½ millions, resulting therefrom, would be all that the United Kingdom could claim as national gain. If British bottoms were used on the occasion, then the amount of national gain would swell by the sums earned in freight, and insurance, and by the benefits arising from the industry, put in motion in consequence of the construction and equipment of the vessels furnished. But, if the question is of foreign, not carrying trade; if the 28½ millions are employed in exporting British goods, in British bottoms, and in bringing back in return raw materials, and other commodities—then the national gains augment beyond calculation, and the merchant's profits sink into comparative insignificance.

In order to reason correctly, *we ought to give credit to foreign trade, for so much of the home trade, as it puts in motion!* Will you attempt to make the calculation? I confess that I should not like, myself, to undertake the task.† But I shall state the principal circumstances that ought to be taken into view.

How many vessels are employed in the foreign trade, and what is the number of artizans, and mechanics that derive their living from the construction and equipment of these vessels?

What numbers derive their support from providing this body of artizans, and mechanics, with food and fuel, covering apparel and lodging?

What proportion of the 28½ millions of property exported, consists of the value of raw materials, imported and paid for; or, of foreign commodities re-exported? For all the rest, being value

* I know no evidence of this in France. I do know, proofs of the most decided character, that this is the case in England. See Anal. Mag. Nov. 1813. T. C.

† The calculation seems to me to be easy enough. A thousand dollars spent at home, in a home-investment, puts in motion one thousand dollars worth of labour at home, and no more. Dr. Bollman's mode of reasoning would tend to prove that it put in motion a million's worth of labour. T. C.

made up by British labour, or British surplus, *is so much clear accession to national gain.* Those, whose labour is thus engaged, may be fairly considered as in foreign pay; and, since the people of England could not possibly consume themselves all their tin, all their copper, all their wool, &c. if you take away their exportation, there will be unquestionably so much diminution of the annual increase of national wealth.

What is the number of those concerned in the raising, or growth, of so much surplus produce exported, or the number of the workmen, whose consolidated labour contributes the principal value of the manufactured goods sent abroad?

What numbers, again, live by providing those with the necessaries and comforts of life?

How many articles are consumed in constructing, improving, and keeping in repair, the labour saving machines, which the foreign trade employs all over the kingdom?

How much industry is kept in motion on high roads, rail roads, canals, and rivers, by foreign intercourse? How much in the towns, by furnishing employment to agents, brokers, underwriters, carriers, and the tribe of clerks? How many husbandmen are at their ease, and exist in comfort, by feeding all these feeders on foreign commerce, together with their train, who give value to country produce by consuming it.

What similar effects are produced by the imports—to an equal amount—the returns from abroad for the commodities sent out?

The foreign trade, you say, requires the navy. Place before your mind's eye all the navy of Great Britain, ready for sea, and ask yourself—what talent, what labour, what industry was necessary to bring this prodigy into existence?* What amount of these would become useless, were it no longer wanted!

Beware of the mistake—if there was no navy those talents, that industry, would be better employed!—Of all our superfluities in food and apparel, of all our luxuries of every denomination, you might say as much. Yet cannot the savage, with his few wants, with his rags and jerked venison, people the wilderness, which disappears before civilized man.

* In my opinion, the man who would devise the means of surely, speedily, and permanently putting *out of existence*, every navy, of every power, in every part of the globe, would be the greatest benefactor to the human race, that mankind have yet known. Let half a dozen merchants in London excite a national clamour that their commerce is in danger, and the British navy carries devastation and death to every corner of the globe. T. C.

In political discussions in particular, we should never ask, 'what man *can*, but what he *will* do?' He will do much, when constantly stimulated, as he is in a great commercial nation, by new objects of desire, brought home from every quarter of the globe; when kept in unceasing wakefulness by an infinite and constantly changing combination, of interests and passions! Remove all this impulse, you see him, as in the interior of the island of Cuba, in the midst of an earthly paradise, surrounded by hundreds of acres, and by innumerable herds of cattle—his own—lying on a skin, and dreaming away a useless existence in apathy and sloth.

Much good, therefore, arises from foreign intercourse, merely as far as it stimulates, as far as it diffuses animation, and life, through the body politic; and perhaps, on allowing their proper weight to the different conditions I have pointed out, you will agree with me, that the benefits of foreign commerce cannot be correctly computed from the mere arithmetical results, exhibited by the balance sheets of the merchants.*

In further contrasting the immense importance of the home, with the insignificance—as you conceive it—of the foreign trade, you compute the amount of the former by estimating the gross, annual, agricultural produce of Great Britain at 150 millions sterling, and the produce of the labour of the manufacturers, and mechanics, for home consumption at 50 millions, which, with a proportionate allowance for Ireland, makes the whole amount of the home trade of the British empire, according to your idea, equal to 220 millions sterling.

But *trade*, agreeable to your own, and correct definition, is barter, is exchange of commodities between different persons.

When a man, therefore, cultivates a potatoe patch, and, after the potatoes have come to maturity, digs them out, and eats them up himself, he can hardly, on that account, pretend to be a trader, nor insist that the value of his potatoes should count in a general computation of the amount of domestic commerce.

Trade requires *circulation*, and when we mean to ascertain the amount of internal circulation, we have obviously to deduct, from the total amount of the proceeds of agricultural, and manufacturing labour, so much as does *not circulate*, that is, so much of the proceeds of their work, as the labourers consume themselves. But, as there are seven millions of cultivators in the British empire,

* No. Nor the evils. T. C.

who may be presumed to have good appetites,—and about five millions of manufacturers, and mechanics,* who probably like to keep themselves warm—these deductions will amount to a great sum.

Great Britain and Ireland, generally, export no grain, but they certainly export a considerable value in linens, and in woollen goods. We have, therefore, in order to find out what the home trade would be, *unaided by foreign trade*, for that is the real point under consideration—we have further to deduct from the value of the *circulating* agricultural produce, so much flax, and wool, as the foreign trade takes off *directly*, in the manufactured state.

We have further to deduct from the value of the same circulating agricultural, and manufacturing produce, so much as he foreign trade takes off *indirectly*, in consequence of the consumption of that vast mass of consumers, whom the foreign trade keeps consuming; for we have seen that so much of the home trade, as is thereby occasioned, is *indirectly foreign*. The foreign trade may justly claim it as its own.

But, if we deduct from the total value of the produce of agriculture, and manufactures,

1. So much as does *not circulate*. And from the portion which does circulate
2. So much as the foreign trade consumes *directly*. And further,
3. So much as it consumes *indirectly*—by which two items home trade would diminish if no foreign trade existed;

Then you will allow that the 220 millions of pounds sterling, which dazzle us in your political arithmetic, will shrink into a sum—*comparatively lean*.†

* The reverse of this, is about the true proportion. The late population returns state the number of families in Great Britain at 2,544,000: of which 895,000 only are employed in agriculture, 1,129,000 in manufactures, trade, and handicraft employments. The very poor, the rich and the professional, amount to 519,000. T. C.

† I see no reason whatever for these deductions. The home trade brings into market the value of consumable produce nearly as I have stated it: no matter how or by whom it is consumed. The value is not lessened whether the consumer be a foreigner or a native. The question is, what is the quantum of industry put in motion; this is measured by the consumable produce raised: it is of no consequence to whom it is disposed of, if its value be obtained. T. C.

The cause of foreign trade might also be pleaded, by leaving all, that I have said, unnoticed, and taking up the question, on the ground on which you have yourself placed it.

" Where is the great source," you ask, in speaking of Great Britain, " of the wealth of that powerful, and wealthy country? It " is in her spirited agriculture," you answer; " in 100 millions " sterling of farming capital, permanently laid out in buildings, in " fences, in roads, in canals, in machines. In 50 millions more, " annually expended in manures, in repairs, in exuberant cultiva-" tion. Here is the secret of 24 bushels of wheat per acre in Eng-" land, 16 in France, and 10 in this country."

But, according to your own statement the *bare mercantile* profits, arising from the foreign trade of Great Britain, and Ireland, amount to three millions and a half of pounds sterling per annum.

Consequently the bare mercantile profits of the foreign commerce of the British empire, with a simple accumulation of only five per cent. per annum, will produce, in the space of nineteen years, more than the whole, fixed, agricultural capital of England.*

In other words—if the mercantile profits, accruing to Great Britain and Ireland from their foreign trade, were every year put out at 5 per cent. interest—they would produce, in the short space of nineteen years, a sum more than sufficient to stock, with the means of wealth, and—of home trade if you please—such another country as England, in a manner equally ample as she is now stocked herself.

The bare mercantile profits, resulting from the foreign trade, re-produce, that is, double, the whole fixed agricultural capital of England in less than nineteen years.

Nay, before they become thus consolidated, and fixed, they will, *if their circulation is rapid*, be more than sufficient to cover the annual expenditure of 50 millions sterling for manures, repairs, and exuberant cultivation.

Thus, on the face of your own statement, *the secret of the secret, is the foreign trade.*

In the prosecution of your arguments against foreign com-

* And what is the agricultural capital doing all this time? Is it dosing during these 19 years? This mode of reasoning will prove any thing. But it is double edged. If the home capital be tenfold greater than the capital of the foreign trade, and this last will earn so large a sum in 19 years, the other will earn ten times that sum. T. C.

merce you further state "*that the lands of America stand particularly in need of capital.*"—I believe they do; and therefore a foreign trade, diverting capital from agriculture, might, in our country, with some plausibility be objected to on that ground.

On the other hand,—a foreign trade, bringing foreign capital into the country, must be the more beneficial, for the same reason.

Which is the case? has not the foreign trade of America, for a long time, been carried on almost exclusively, with British funds? and was not a great proportion of it carried on, with British funds, down to the very moment of its late interruption?

The great influx of foreign capital, in consequence of foreign trade, and of the funding system, so frequently, and so improperly found fault with, is, unquestionably, one of the most powerful causes of the unexampled progress which agriculture, the arts, and manufactures, have made in this country during the short space of a century and a half—for it has not been longer settled. Foreign trade, and the funding system, are the very *hot beds*, in which they have so surprisingly thriven.

If there were no other arguments in favour of an unrestrained, commercial intercourse between nations, a view of the benefits derived from the influx of capital on the one side, and from the employment of capital, on the other, would alone be sufficient to establish firmly the doctrine of its superior usefulness.

Since capital consists, in the accumulated, and consolidated results of labour, during a lapse of ages of industry; it surely follows, that a young nation, secluding itself, and avoiding all intercourse with foreign nations, has to become *old*, before it can acquire a capital of its own, and enjoy the incalculable advantages it procures.* A young nation, on the contrary, communicating freely with nations of long standing, will participate largely of the advantages they derive from the labours of their ancestors.

To place this in a still stronger light—suppose a family, possessing absolutely nothing, should arrive and settle on a fruitful spot, and be left there to themselves. They will first have to *scratch* the ground, to raise the grain wherewith to satisfy their hunger, and, if possible, the surplus grain, wherewith to procure

* I cannot see this. Is the commerce between Philadelphia and New-Orleans, good for nothing, until they become foreign countries in respect of each other? Is it the worse, because it requires no navy at each place to be ready for mutual hostilities, whenever mercantile jealousy shall excite them? T. C.

a spade, and a cow. The spade, and cow must earn a plough and horse, and so on, in slow succession. Years will elapse before they can attain a tolerable degree of ease, exert their faculties to the best advantage, and make the most of their farm.

An untoward accident during this period may altogether destroy them. If, on the contrary, some rich neighbour, relying on their industry, on the fertility of their ground, had, for a due eventual consideration, supplied them at once, with all the stock, and implements, required for good farming, his capital would have placed them nearly in the same situation, as if they had been already at work for years; their exertions would have yielded greater results; their situation would have been infinitely less precarious, and they would have attained, comfort first, and, afterwards, independence and wealth, with much more rapidity.

If immediately after the termination of the revolutionary war, in this country, a non-intercourse with all foreign nations had been decreed, and enforced to this hour; if, previously to the revolution, as soon as the first settlements had taken place on this side of the Atlantic, all connexion with Europe had ceased—can it be imagined that our agriculture, that generally, our prosperity, would have by this time attained the height to which they have risen?*

Capital itself is a commodity, which, when uncontrouled, migrates from the country where it abounds, to that where it is wanted.

British capital, in the first instance, stocked our farms. British, and other foreign capital lined our shores with ships, and covered our rivers with small craft. Nine out of ten, of our manufacturing establishments, have been set on foot by foreign skill, and with foreign funds.

The profits of capitals lessen in proportion as their size augments. A young beginner, with small means, must work hard to live. Grown wealthy, the bare interest of his accumulations suffices for his wants, and he seeks ease. He therefore sets up another in business, and is content with a share of the profits. Thus both benefit. The former makes rapid strides towards acquiring a capital himself, and the latter derives from his means an income without labour.

* No. Foreign commerce is highly desirable on many accounts, while it can be pursued, peaceably. The question is, ought we in prudence to go to war for the sake of it? will it repay the cost? T. C.

It is just so between nations. The same benefits are realized by foreign intercourse, and foreign commerce, *without any previous concert.* They are the natural results of difference of situation and circumstances, and of the operation of the ever active, universally prevailing desire, to improve, in the best manner, the advantages possessed.

Thus your observation—that American lands want capital—considered with a view to ultimate effects, corroborates, instead of disproving, the great utility of foreign trade.—

" *Capital,* you pursue, *employed in the foreign trade, is more* " *exposed than capital employed in domestic trade.*"—True! but a trade, the profits of which do not cover the premium of insurance is not pursued.—We may insure, abroad or at home.

" *The merchant, and all the people employed directly by him,* " *rank among the unproductive classes of society.*"

It is time indeed the invidious distinction of productive, and unproductive classes should disappear from the pages of political economy.

There are no unproductive classes,* unless it be the class of gamblers; and even their activity might be proved to be less injurious than perfect idleness. But the proceeds of labour are not always *direct*, and *tangible.*

If you spend six weeks in reflection, and thinking, and afterwards two hours in explaining to an intelligent mechanic some new principle, which you have discovered, and the application of which enables him to accomplish his usual work, in half the usual

* By unproductive persons, are meant those whose labour is not employed to increase the mass of consumable product, such as food, cloathing, furniture, the comforts and conveniences of life, &c. It is evident that a farmer, a mechanic, an engineer, does this, directly or indirectly. How does M. Vestris or Madame Catalini do this? It seems to me a strange mingling of words and ideas, that should regard as equally productive, the farmer, whose time is spent in producing food, and the idle class of gentlemen, who have nothing to do but devour it: *fruges consumere nati.* This is like the reasoning of the British ministry, who reckon all their expenditures in wars abroad, naval or military—all the money they waste, as so many, not merely evidences of, but additions to the mass of national wealth. So that if half a dozen line of battle ships be sunk or destroyed, the nation is the gainer by all the industry which is put in motion by the sums expended to replace them. This may be good reasoning in England; but I cannot comprehend the force of it.
T. C.

time;—when you have finished, there remains no result of your labour that could be measured, or weighed. But, if the day following, and ever after, the industry of your hearer is equal to twofold the wonted task, who will say that your labour has been unproductive? you have doubled the usefulness of his existence.

What remains of the activity of congress, after they have risen? yet, a few sentences, passed into a law, and handed over to the chief magistrate, for execution, will animate, or paralyze the industry of unnumbered individuals, encourage honest pursuits, by security of reward, or drive whole classes at once as we see daily, by the magnitude of illicit gains, or the necessity of finding the means of subsistence; into the paths of smuggling, imposition, and fraud.

Say, and after him the distinguished American commentator of the great Montesquieu,* call merchants *manufacturers of peace*. The idea is somewhat quaint. It seems difficult, for us people of common sense, to conceive how space, unbounded, could be something fabricated, or even the occupancy of any defined section of it—peace—a production!—According to the same commenting luminary, the soil is only a *tool* in the hands of the husbandman, who manufactures wheat. By parity of reasoning, cows and bulls are the instruments of the breeder; and our graziers manufacture beef, by means of a judicious application of oxen to pasture!†

But—leaving such sublime conceits to those who, strangely enough, imagine that they soar with Montesquieu in kindred regions, or even presume to look down upon him with a sneer—I believe there is a species of commodity the importance of which has long been generally felt, and at which a plain intellect will not revolt, when it is brought into notice. I mean *convenience*.

* A commentary,

The shades of Monticello are particularly familiar to the author, who, with a candour, tout a fait unique! avows himself, in the preface, to be a Frenchman. Dr. B.

The commentary on Montesquieu, was written in French, by a Frenchman. It is too theoretical and too democratic for me in some parts; but I consider it as a work of considerable merit, and well worth perusing. T. C.

† I see nothing ridiculous in this view of the subject. It seems to me as substantially true, that a grazier manufactures beef, by applying the proper kind of food to his oxen, as that a cabinet-maker manufactures a chest of drawers, by applying the proper instruments to his log of mahogany. We might as well indeed keep to common language, which distinguishes them, but there is not much real distinction in the case. T. C.

Of this commodity, *convenience*, all traders and merchants, may truly claim the production, and its influence, on the general productiveness of labour, is incalculably great.

Without an exchange of the commodities produced, there could exist no division of labour. But, how many exchanges would take place, if the consumers were obliged themselves to *seek*, and *directly to traffic* with, the producers, or manufacturers? The enormous waste of time, which such a mode of supplying wants must occasion, would, inevitably, destroy all the advantages resulting from the division of labour—which would therefore *cease*—and render half the treasures of nature, and industry, useless, in consequence of their being placed, morally, beyond the reach of consumption.

The merchants, therefore, with their train, *create value, by creating convenience of consumption.* Without them, division of labour, if it existed at all, could not be carried to an equal extent. Without them, half the time of those whose labour is allowed to be productive, would be wasted in an unproductive manner. This obliges us to admit, that their activity, if not *directly* is at least *indirectly* productive. Their labours add nothing to the mass of matter, nor improve its form; but they cause, notwithstanding, more work to be performed, and the same amount of *directly productive* labour, to yield larger results, by being more advantageously applied.

If the industry of a million of people, without merchants, realizes the value of one million of dollars per annum, and, by turning one fifth of them into traders, and merchants, their industry yields, annually, the value of two millions of dollars, will any statesman say, that the labour of merchants is unproductive, and that they are to society a burthen rather than a benefit? Those who distribute tasks, and provide every department with the needful, are not the least needful in a large manufacturing concern. What interests society is the quantum of work performed, and if the greatest result were obtained, by causing a portion of the large family to be *idle*—the very *idleness* of these ought to be termed *productive*.

The same observations apply to those, whose offices are required for the maintenance of security, and for defence. I can see nothing unproductive in any of the situations, which an improved state of society, and great civilization, have brought forth. Cultivators, merchants, manufacturers, tradesmen; the officers of

government, judges and lawyers ; soldiers, clergymen,—physicians even—all are useful ;* all contribute, materially, to swell the great aggregate proceeds of general industry, provided their number do not exceed the due proportion.

No objection can therefore lie against foreign trade, because it requires merchants. On the contrary, the usefulness of this class of society—which, perhaps, has never yet been duly appreciated—is of the highest order.† The beneficial results of their labours—though only *indirectly productive*—are immense, and there is this peculiarity attending them, that often their contribution to the general wealth of society, and to its *beneficial distribution*, is great, in proportion as a sanguine disposition has caused them to provide but ill for their own.

" *Mercantile success*, you continue, *tempts to imprudent expenditure, and speculation*."

I doubt the correctness of the observation, which, if true, would only be of minor importance. Mercantile success generally causes an increase of caution, and a greater desire to accumulate. Those who have acquired fortunes, mostly continue to enlarge them. Imprudent expenditure is more commonly the fault of wealthy landholders than of wealthy merchants. A speculation which ruins the speculator, not unfrequently enriches the country !

" *Merchants are of no country*." Professionally they are not. Nor are they learned ! Will you therefore banish the learned ? Both may be patriots as men. A merchant at least, as such, always belongs to the country in which he resides. Where he trades, there his existence is beneficial. Of the learned, and even of many of our politicians, you cannot always say as much !

It is an erroneous idea, that merchants, by any effort of theirs, could set on foot, or cause to continue for any length of time, a foreign trade, injurious to the country.—Trade is exchange. There must be something that can be spared, before the reception of an equivalent is practicable. The equivalent received,

* No doubt : because all these classes are more or less necessary, directly or indirectly to the increase of consumable produce. But I cannot see how a Gamester, a Dancer, an Actor is so. They put industry into motion and give employment to many persons who might be more usefully employed. But their efforts add nothing to the stock of national wealth. Ipso usu consumuntur. T. C.

† I acknowledge that merchants and factors, are fairly to be considered in the same light as labour-saving machines. T. C.

must have a greater *relative value*, must be preferred, else the price would not be given. Nor will the importation of any commodity continue, as soon as the same commodity can be produced cheaper, or better at home. The merchant, in all his operations, is inevitably controuled by the nature of things. Should he attempt defiance—he will be ruined, and disappear.

"*Foreign commerce has never paid the interest of the sums spent in the prosecution of the expensive wars it has induced.*"

As you, and myself, value somewhat differently the benefits resulting from foreign commerce, we could also not well agree with regard to the amount of national expenditure for which they would compensate. If those benefits are so great, as I am inclined to think they are, the weight of your argument falls to the ground.

Independently of this, I cannot admit, that foreign commerce is the cause of all modern wars. This idea has seized on your imagination so forcibly, that it re-appears on almost every page of your political discussions—but is it true?* Or ought we not rather to say, that the passions of those who rule, have, in our modern times, found in the collisions caused by foreign commerce, the most convenient, and popular *pretext* for the wars which their gratification demanded!

I will not advert to our own situation at this moment. I will not say, that any rooted animosities, or inveterate prejudices of leading politicians; or the ever active, and unabating thirst for vengeance of a considerable body of foreigners, whom personal wrongs drove from their native shores, had the least share in bringing it about. I will not question that the western people, and particularly those of Kentucky, would be equally zealous in the defence of injured sailors rights, even if the war, in which we are engaged, should have drained their country of circulating medium, instead of making it abound; even if their produce should have

* I think it is. Look through the history of the European wars particularly those of England, and it will be found so. It is not a little singular that in 1738, the king, the lords, the commons, and the British people were actually outrageous in support of the principle that FREE SHIPS MAKE FREE GOODS. Sir Robert Walpole could not withstand the torrent; and one of the most efficient causes of his ultimate dismissal, was, that he did not take care to insert this principle as a national right, in his convention at PARDO; a right, in defence of which, the British nation actually went to war with Spain in 1739. Flags were displayed, and cockades worn in almost every town of the kingdom with mottoes such as FREE TRADE: NO SEARCH. *Tempora mutantur.* T. C.

sunk in value, in consequence of that event, as much as it has risen; even if the price of their saltpetre instead of an augmentation from 12½ cents per pound to 40 cents, should have experienced a proportionate depression. But let us look to Europe.

The recent pages of French diplomacy ring with splendid sentences in defence of neutral commerce. The philanthropic Napoleon steps forth the champion of injured maritime rights.* He, who knows no law but his will, is the great expounder of the law of nations; he, who respects no nation on terra firma, insists that the most insignificant should be respected at sea; and a *Tuscan*, his sword still reeking with the slaughter of pious fanatics, attempts to insult our government for not joining with sufficient alacrity in the common cause!

Is it the less true that *Napoleon* hates, and must hate, Great Britain; that he only seeks to destroy her supremacy on the ocean to be able to assume it himself?†

The commercial intercourse between nations, on an extensive scale, is of recent origin. Was antiquity less drenched in blood, because then such intercourse was unknown?—The Romans were not commercial—and they desolated the world. The Tartar tribes, with their herds, and their milk, subdued in their turn the Romans. The sword of the Turks spread devastation in Asia and Europe. Millions perished in the crusades. Religious feuds, subsequently, swallowed up a whole generation.—Yet, you would attribute the sufferings of nations in our times, to the sublime, though still imperfect policy, of linking all by ties of mutual usefulness!

"*The modern system of foreign commerce is the most productive source of human misery.*"

We have enjoyed foreign commerce, and we have to bear our share of human misery—it is granted. But misery bore not less hard on the human race before our time.‡—You wish for the de-

* If Dr. Bollman will look at the state papers and manifestoes of the European powers at the time when Russia proposed the *armed neutrality*, he will find that FREE SHIPS, FREE GOODS, was then adopted as a principle of maritime law, by every maritime nation of Europe except Great Britain. I do not undertake the impossible task of defending Buonaparte, but he will not suffer by a comparison with his European contemporaries. T. C.

† An American ought to have no objection to these two powers worrying each other, till neither is able to usurp this hateful supremacy. T. C.

‡ Many of the antient sources of war, are done away. Is it absolutely needful that mercantile jealousy should furnish others to supply their place? T. C.

struction of all men of war. I, on the contrary, should hail him as the greatest benefactor of mankind, who should cause all national quarrels to be settled by seventy-fours.—If they were thus divided on the ocean, the labours of ages would become heaped on each other, and the accumulation of improvements and capital would be prodigious!

* Has not, in Europe, the introduction of the potatoe fattened millions, and called additional millions into existence? Has not the introduction of sugar changed the catalogue of diseases, and expunged one half from the former list?† Has not the introduction of cotton goods spread taste, and neatness, where before prevailed grossness, and filth?‡ Does modern civilized society know of any more universal and more inabuseable means of comfort, in health, or of solace, in pain, than coffee and tea? and are they not all the result of foreign commerce?§

You say, that colonization is the immediate offspring of foreign trade; and you will certainly grant, that these United States are the offspring of colonization!—well, I plead the cause of foreign commerce with these United States. They shall be my great argument.‖ I put into my scale of the question all this noble land, with its eight millions of people,—most miserable, and most wretched, as they are—all the population of the day, all the population of the times to come!—What have you to put into yours?

"*The most flourishing, populous, and best cultivated parts of Europe*, you say, *are not maritime, or commercial.*"

But, in endeavouring to elucidate this point, you confine yourself to numbers; and a mere superiority of numbers per square

* No. The consumption of potatoes as an *article of food*, is confined to Ireland. They are used here and in England, as a sauce, or condiment—an addition and auxiliary to the table. In 1792, in France they were almost unknown. Brissot and Claviere introduced them. T. C.

† Not that I know. T. C.

‡ Cotton goods, have introduced cleanliness and the consumption, Pthisis. T. C.

§ They may perhaps be somewhat pleasanter from being more fashionable than Balm, Sage, Chicory or Beet: I do not know that they are better in any respect. T. C.

‖ I cannot urge all that is to be urged on this subject. Those who desire to know the comparitive value of colonies to a mother country, must peruse Anderson and De Casaux. Ganilh talks absolute nonsense on the subject. T. C.

mile, does not establish the existence of a superior degree of individual prosperity, or of national wealth and power.*

There can be no doubt that, if in England you were to cut up, all the large estates into very small farms of ten, and fifteen acres each; if you were to turn all the pasture, and pleasure grounds, into wheat and potatoe fields, make men and women perform the labour of oxen and horses, and habituate the present hardy race to a meagre diet—you might succeed in adding one third, or perhaps, one half, to its present population. But England would then be no longer what she is! She would present, like China, or Flanders, a surface crowded with beings, scarcely human, all absorbed in barely prolonging a miserable existence.†— Instead of British cottagers, and farmers, you would have Egyptian fellahs,—an easy harvest for the sword of any invader! an useless load to the soil they encumber!

Here is one of the secrets of Bonaparte's successes.—There is no statesman, there is no philosopher, there is no philanthropist, who could not prefer, for their sake, and for his own, the 150 per square mile in England, or, even the still fewer per square mile in this country, to the 244 in Italy, or the 333 in China!‡

"*The commercial nations have uniformly fallen before the agricultural nations.*"

But no nation ought to be, or can be, exclusively commercial. But, in complicated questions, all vague appeals to history are extremely apt to lead to false conclusions. But we know so little of the people of Tyre, and of Sidon. But Tyre, and Sidon, and Carthage, which you adduce in proof, existed as nations previously

* It does under a good government: according to the principles laid down by Dr. Bollman in the beginning of this essay; to which I give my full assent. "That system of political economy is the best, which affords comfortable subsistence to the greatest number of persons upon the smallest territory; provided the system be permanent in its principles." If then we see a country very full of inhabitants, living in reasonable plenty and comfort, we have a right to conclude accordingly. T. C.

† England is in fact at the present moment, and has for many years been, *crowded* with beings who drag out a miserable existence. It is true that lately the war has thinned them, and created something nearer to a sufficiency to support life for the rest: but where else is the country, where one eighth of the population are paupers? Soon after the peace of Amiens, in 1803, the poor's rates of England, amounted to 5,318,000 pounds: the returns were again to be made this year, 1813: but I have yet seen no acount of them.

T. C.

‡ I regard China as greatly exaggerated. T. C.

to the Romans;—the struggle between the two latter remained long undecided, and was at last decided by superiority of tactics, and military genius, more perhaps than by their superior estimation of agricultural pursuits. But the agricultural Romans were themselves overcome by the Huns, and Vandals,*—must we therefore take our lessons of political economy from these?

Permit me to conclude my remarks in vindication of foreign commerce, by adding one more argument to those adduced already, the force of which, it appears to me, cannot be easily resisted.

The wealth of a nation, as you have stated, consists in the aggregate wealth of the individuals of which it is composed.

Nine tenths of the population of almost every country are engaged in agriculture, and manufacturing pursuits.

The wealth of a nation, therefore, *depends chiefly* on the prosperous condition of these.—The lazaroni of Naples, the fellahs of Egypt, the zaragottas of Mexico, the canaille of any country, add nothing to the wealth, or power, of the political families to whom they belong.

But the condition of these, engaged in agricultural, and manufacturing pursuits, cannot be prosperous, unless the rewards of their labour somewhat exceed the measure, indispensible for the bare support of animal life.

Now in any fully peopled country, the price of any species of produce, or commodity, within the reach of general competition, can only be maintained above the rate, which the bare support of animal life requires, by means of foreign commerce.

The reason cannot be mistaken.—Domestic consumption is limited, whilst only want of food can limit population. Therefore competition, or, in other words, the struggle for existence, will always bring the supply of the great mass of domestic commodities full up to the demand, and prices must consequently sink down to the lowest rates.†

* The Huns and Vandals had no foreign trade. T. C.

† True: in a country overpopulated, and badly governed. It is so in England, where the preference in foreign markets is chiefly owing to the low price of the commodities: a low price, dependant on the intolerable labour, and hard living of a starving manufacturing populace. The profits of the capitalist—the commerce of the nation is supported out of the life-blood of the labouring peasant and manufacturer. T. C.

Foreign consumption, on the contrary, has no limits, and the merchants—the agents between domestic producers, and foreign consumers, are constantly on the watch to extend its sphere.

Therefore foreign commerce is the surest, and perhaps the only means, of maintaining the staple commodities of a nation, at prices which will insure to the mass of the people the enjoyment of substantial comforts, and allow them to be rational beings, and men, instead of mere drudges, and beasts of burthen.

LAUDERDALE has well described the surprising effects of a little deficiency, or excess, in the supply of a commodity, on its market-value.* A trifling quantity less in the market, than the demand would require, often doubles the price of the whole stock on hand.—A trifling excess, as rapidly brings it down. But, when the holders are not in distressed circumstances, the *rise* from a demand, in the smallest degree larger than common, is much more certain, quick, and considerable, than *depression* from the opposite cause.

When I shewed before, how the supposed information of a deficiency of crops in England, and the consequent exportation of 200,000 blls. of flour, caused the country to gain 1,200,000 dollars, though the merchants lost money by their speculation, I did not pursue the consequences further; because my only object was, to shew immediate, numerical accession to the national wealth, in consequence of the foreign, commercial operation, to which that information had led. It is obvious, however, that, on account of the general advance of the price of flour, caused, in the supposed case, by the foreign demand, *the domestic consumers of that article also, had to pay* $12 *instead of* $8.

If this domestic consumption throughout the Atlantic states, amounted, during the elevation of the price, in consequence of foreign demand, to 500,000 barrels, then the foreign demand, though, in its direct effects, worth to the nation only $1,200,000, would be worth, to the agricultural interest, two millions of dollars besides.—The home trade, according to your mode of estimating it, would be indebted to the foreign trade, for an immediate, additional importance to the amount of the stated sum. But, what is of infinitely more consequence, the millers, and farmers, would receive an additional compensation of two millions of dollars for their labour, *through the home trade, as operated upon by the foreign trade;* this shews, that the foreign trade prevents the consumers

* An inquiry into the nature and origin of public wealth.

from making the law to the producers, with regard to price;—that it is one of the most powerful means *of a general distribution of wealth;* and that, in consequence of this distribution, wealth becomes more productive of wealth; becomes more productive of national power; becomes, in every point of view, more beneficial to the state.

Such are the *great home effects*, of even a *little exportation.* I am well aware that a surplus in the market, in consequence of a want of the usual demand for an article from abroad, must operate the contrary way.—But, this evil is casual, whilst a depressed value of the great articles of consumption—which becomes *stationary*—and the poverty of the great mass of the people, thence ensuing, *are certain*, and *regular results of a want of foreign trade.*

Moreover—in this state of things the people naturally remain without relief, whilst in the former, the ingenuity, and enterprise of the merchants, prompted by self-interest, are unremittingly, exerted to provide a remedy.—The calamities to which a nation is subject from the want of foreign trade, can only be removed by the greater calamities of famine, pestilence, and war. The resources against these, to which, even with a foreign trade, they remain occasionally subject, are found in mercantile skill, and are commensurate with the extent of the globe.

Extract from Quart. Review for December 1812. *Inquiry into the poor laws, &c.*

I do not cite this book from any deference I pay to the opinions of the persons who write for it, or from any admiration of the ability or knowledge with which it is conducted, it is far from deficient in classical literature, but it does not and cannot maintain its ground against the Edinburgh Review, which is certainly conducted with much occasional talent. From the circumstance of the writers being anonymous, both reviews assume a stile of ungentlemanly insolence, that would not appear, if the names of the writers appeared also. But with far inferior merit, the tone of vulgar abuse, which the Quarterly Review indulges in, and the canting affectation of orthodoxy that characterises it, are extremely offensive.

I quote the following passage, as an advocate in court would press into his service adversary evidence.—

The system of Great Britain, is a system of manufacture founded on foreign commerce; and it is to this system that the following remarks apply, and they apply very forcibly. I do not choose to copy the abuse which this writer heaps on Malthus, Adam Smith, &c. for my object is to instruct, not disgust my readers.

But during the last forty years, a tremendous change has been going on; it has affected all classes, few for the better, the lowest and most numerous much for the worse.

One chief cause of this great moral revolution, for such it may truly be called, is to be found in the improvement of machinery, and the consequent rapid increase of manufactures. The manufacturing system has been carried among us to an extent unheard of in any former age or country; it has enabled us to raise a revenue which twenty years ago we ourselves should have thought it impossible to support, and it has added even more to the activity of the country than to its ostensible wealth; but in a far greater degree perhaps, has it diminished its happiness and lessened its security.****

Some of the sciences and many of the arts require large cities to foster them; they thrive there like exotics in a town-conservatory; but the virtues and the comforts of inferior life wither away in such atmospheres, like flowers transplanted from the field to pine at a street-window. The peasant, however much his religious education may be neglected, cannot grow up without receiving some of the natural and softening impressions of religion. Sunday is to him a day of rest, not of dissipation: the sabbath bells come to his ear with a sweet and tranquillizing sound; and though he may be inattentive to the services of the church, and uninstructed in its tenets, still the church and the church-yard are to him sacred things: there is the font in which he was baptized, the altar at which his parents became man and wife, the place where they and their fathers before them have listened to the word of God, the graves wherein they have been laid to rest in the Lord, and where he is one day to be laid beside them. Alas for him, who cannot comprehend how these things act upon the human heart! The town manufacturer is removed from all these gentle and genial influences; he has no love for his birth-place, or his dwelling-place, and cares nothing for the soil in which he strikes no root. One source of patriotism is thus destroyed; for in the multitude, patriotism grows out of local attachments. *Omne solum forti patria* may be said by the exile and the cosmopolite philosopher, but *natale solum* is found among the periphrases for *patria*, and the same feeling will be found in the language of every people who are advanced one degree beyond the savage state.

The manufacturing poor are also removed from other causes which are instrumental to good conduct in the agricultural classes. They have necessarily less of that attachment to their employers which arises from long connection, and the remembrance of kind offices received, and faithful services performed,—an inheritance transmitted from parent to son: and being gathered together in herds from distant parts, they have no family character to support in the place to which they have been transplanted. Their employments, too, unlike those of the handicraft and the agriculturist, are usually so conducted as to be equally pernicious to mind and body. The consumption of life in some manufactories, even in those which might at first be thought most innocuous, though it may be a consolation to those philosophers who are afraid of being crowded at the table of nature, would make good men shudder if the account could be fully laid before them.

John Hunter predicted that our manufactories would engender new varieties of pestilence. New and specific diseases they have

produced, but the only pestilence which has yet manifested itself is of a moral nature. Physical diseases are not more surely generated by crowding human beings together in a state of filth and wretchedness, than moral ones by herding them together in a state of ignorance. This is the case under the least unfavourable circumstances which can be imagined; but it is doubly so under the manufacturing system, where children are trained up in the way wherein that system destines them to go, as soon as their little fingers can twirl a thread, or feed a machine. When that system was at its height, the slave-trade itself was scarcely more systematically remorseless. The London work-houses supplied children by waggon loads to those manufactories which would take them off the hands of the parish; a new sort of trade was invented, a set of child-jobbers travelled the country, procuring children from parents whose poverty was such as to consent to the sacrifice, and undertaking to feed, clothe and lodge them for the profits of their labour. In this manner were many of our great manufactories supplied! The machinery never stood still. One set of these poor children worked by day, another by night, and when one relay was relieved, they turned into the beds which had been vacated by the other, warm as the others had left them!—When this system had continued long enough for those who lived through so unnatural a childhood to reach the age of maturity, it was found that the girls, when they married, were utterly unable to perform the commonest and most indispensable domestic work: and the remedy which was devised, in future, was that they should go to school to learn these things for an hour in the day, after they had done work!

These evils have been mitigated: the hellish practice of night-work (it deserves no gentler qualification) is nearly, if not totally disused; but enough which is evil remains to produce irreparable injury to the individuals and the most serious mischief to the community. The existing race of the manufacturing poor have been trained up certainly without moral, and it may be said, without religious instruction also; for if a pulpit lesson should now and then by accident reach their ears, there is little chance of its penetrating farther, utterly unprepared as they are to receive it. Among the philosophers-errant who mislead themselves as well as others in confounding the distinctions between right and wrong, there are some who, after wandering about the debatable ground between good and evil, recover the right path, and find grace to thank Providence for their escape. The bias inclines that way in the middle and higher ranks; for morals, as well as manners, follow the mode, and decorum, at least, is in fashion. But the class of which we have been speaking, have more to resist, at the same time that they are less prepared for resistance. He who has ever seen the habitations of the city-poor in the cellars and garrets of courts and alleys, will easily believe that the fire side of the pot-house holds out a stronger temptation than even the physical effect of the liquor. Goldsmith has told us how such places

'impart
An hour's importance to the poor man's heart;'

But they do more than this: they afford a stimulus of society which he cannot find elsewhere; strong humour and vulgar wit come

with double fascination to those whose intellectual powers are stagnant at home; the coarseness of boisterous mirth acts upon them with double excitement; and if they give themselves up to the lowest vices, ought we to wonder at this, when their better faculties have never been brought into action? Scarce lower than the angels in the capacity of his nature, man is yet, when left to himself, scarcely above the brutes; and if he be depraved, as well as ignorant, he is then chiefly distinguished from them by the fatal prerogative of possessing a wicked will and greater powers of mischief. When his diviner part has never been called forth, the mere animal is all that remains, and mere animal gratification must be the natural end and aim of his blind desires.

These are not the mere imaginations of a speculative moralist. It is notorious that the manners of the people in manufacturing districts are peculiarly dissolute. Saint Monday is the only saint in the journeyman's calendar; and there are many places where one of the working-days of the week is regularly set apart for drunkenness, like a sabbath of irreligion. However high the wages may be, profligacy of every kind keeps pace and draws after it its inevitable punishment of debility, disease, poverty, want, and early death. For the main cause of the increase of pauperism it is needless to go farther than the increase of manufactures,—that very increase which has so often been triumphantly appealed to in proof of the prosperity of the country. Even in quiet times, and when to all outward appearances, the country was flourishing beyond all example in former ages, the evil was felt, an evil in itself of sufficient magnitude, but of the most frightful nature when those circumstances are considered which give it a direct political bearing. This tendency was noticed some years ago in Espriella's Letters, a book in which, amid lighter matter, grave subjects are sometimes touched with a deeper spirit of thought than appears upon the surface.

'Two causes,' says the author of that book, 'and only two will rouse a peasantry to rebellion; intolerable oppression, or religious zeal either for the right faith or the wrong: no other motive is powerful enough. A manufacturing poor is more easily instigated to revolt. They have no local attachments; the persons to whom they look up for support they regard more with envy than respect, as men who grow rich by their labour; they know enough of what is passing in the political world to think themselves politicians; they feel the whole burthen of taxation, which is not the case with the peasant, because he raises a great part of his own food; they are aware of their own numbers; and the moral feelings which in the peasant are only blunted are in these men debauched. A manufacturing populace is always ripe for rioting: the direction which this fury may take is accidental. In 1780 it ran against the Catholics; in 1790 against the dissenters. Governments who found their prosperity upon manufactures sleep upon gunpowder.

'Do I then think,' continues the writer, 'that England is in danger of revolution? If the manufacturing system continues to be extended, increasing as it necessarily does increase, the number, the misery, and the depravity of the poor, I believe that revo-

lution inevitably must come, and in its most fearful shape. That system, if it continues to increase, will more effectually tend to ruin England than all the might and all the machinations of her enemies were they ten times more formidable than they are. It communicates just knowledge enough to the populace to make them dangerous, and it poisons their morals. The temper of the mob has been manifested at the death of Despard, and there is no reason to suppose that it is not the same in all other great towns as in London. It will be well for England when her cities shall decrease, and her villages multiply and grow; when there shall be fewer streets and more cottages. The tendency of the present system is to convert the peasantry into poor; her policy should be to reverse this, and to convert the poor into peasantry; to increase them and to enlighten them; for their numbers are the strength, and their knowledge is the security of states.' * * * * * *

Among the circumstances that favour the disorganization of the lower orders, the manufacturing system again presents itself in the first rank. *The extent to which it has been carried, makes a large part of our population dependent for employ, which is, in fact, for subsistence, upon other countries; and when the tyranny of a frantic barbarian in Europe, and the servility or corruption of a ruling faction in America, shuts us out from our accustomed market, distress and riots in the manufacturing districts are the consequence.* Let it not be supposed that we are among the wholesale declaimers against foreign commerce; or that, because we perceive the fatal consequences which result from the manufacturing system, carried on as it has hitherto been, we would, in the spirit of radical reform, destroy it root and branch. Doubtless it has been productive of great and essential benefit. But as nations may be too warlike for their own happiness, or even their own security, so they may be too commercial. * * * * * *

In other times we have had men thrown out of employ by the fluctuations of foreign politics, but their numbers have been comparatively trifling, and the effect partial; nor were there in those days public speakers and public writers ready to inflame their discontents and array them against their rulers. The rapid increase of manufactures, and the wider scale upon which hostility is carried on against us, have caused the effect now to be felt over every part of the country; and a cause which arises out of our real improvement and the high civilization to which we have attained, has given consistency to the danger. * * * * * *

The first duty of government is to stop the contagion; the next, as far as possible, to remove the causes which have pre-disposed so large a part of the populace for receiving it. We shall do little if we do not guard against a recurrence of the danger by wise and extensive measures of prospective policy. The anarchists may be silenced, and the associations of their disciples broken up; but while the poor continue what they are, continuing also, as they must, to gain in number upon the more prosperous classes, the materials for explosion will always be under our feet.

The first and most urgent business is to provide relief for those upon whom the pressure of the times bears hardest. Charity is no where so abundantly and munificently displayed as in England, not even in those countries where alms-giving is considered as a com-

mutation for sin; but mere charity is not what is needed in this emergency. The various plans which have been devised, and the local and partial experiments which have been made for bettering the condition of the poor, as reported by the society embodied for that purpose, are highly honourable to the members of that society, and to the land in which they exist. The society which has been formed under the auspices of the Duke of York, for the immediate purpose of affording assistance to the distressed counties, is doing much; and there is cause to hope that the benefit which must result from its encouragement of the fisheries will continue after the emergency is past. The food which is thus brought into the market is so much clear gain; it is nutricious; it is the cheapest which can possibly be procured; it is drawn from a source of supply which is inexhaustible, and the mode of procuring it adds to our best defence, by keeping up a nursery for our fleets.

There is another way by which employment might be provided for many of those whom want of work renders not only burthensome, but dangerous to society, and from which permanent good would ensue to the community. These ends might be attained, if our great landholders could be persuaded, instead of adding estate to estate, till they count whole districts, and almost whole counties within their domains, to apply the capital, that is thus directed, to the better purpose of doubling the value of the lands which they already possess, by bringing them into the highest state of cultivation of which they are capable. How many are the marshes which might thus be drained, the moors which might be reclaimed, the wild and lonely heaths which would be rendered productive, and where villages would grow round the first rude huts of the labourers! Great indeed is the present relief which might thus be afforded to those who need it, the permanent advantage to the country, and ultimately to the principal landholders themselves: but that they should thus see their true interest, and act upon it, is rather to be wished than expected. Of all the maxims of proverbial wisdom which experience has bequeathed to mankind, there is none which is so seldom practically applied, and few which are so widely applicable, as that which is contained in the old Ascræan's exclamation,

Fools do not know, that the half may be more than the whole.

It may seem, perhaps, paradoxical at first to assert that a season of pressure like the present, is a fit season for undertaking national works; yet nothing can be more certain, than that the public must in some form or other, support those who are deprived of their usual employments; and that it is better to administer this relief in the form of wages, than of poor-rates. The mouths cannot be idle, and as the great object is to prevent the hands from being so, a time when there are many hands out of employ is, of all others, the time for such labours. One way or other, be it remembered, the men must be maintained: it is therefore more wholesome for the community to have the advantage of their labour, and for themselves to feel that they earn their own maintenance, than that they should be fed gratuitously, and that we should have a race in England half Luddite, half Lazzaroni. No time, therefore, can be so proper for national works, for making new naval stations and improving the old, for cutting roads, draining fens, and recovering

tracts of country by embankments from the sea. Better is it to engage in works of ostentatious convenience,—better would it be for the state to build pyramids in honour of our Nelsons and Wellingtons, than that men who have hands, and are willing to work, should hunger for want of employment.

Things of this kind (and many such might be devised) are palliatives, which in this case are all that are required; this part of the evil being but for a season. The radical evil can only be cured by a course of alteratives. * * * * * *

Reverting to immediate relief, as well as permanent good, why should not government extend its military and naval seminaries, so that every body who needed an asylum should know where to find one? Would it not be better that the workhouses should empty themselves into our fleets and armies, than that they should pack off children by waggon-loads, to grow up in the stench and moral contagion of cotton mills while the trade flourishes, and to be thrown out of employ, and turned upon the public when it meets with any sudden revulsion? Seminaries of this kind may be so conducted as to cost little more than well regulated workhouses. Boys become useful at sea at a very early age. There is no danger of overstocking ourselves with seamen; in peace the merchant service will require all that the navy can dismiss, and in war we know what is suffered from the difficulty of procuring hands. Train up children for the land and sea service, instruct them too in their moral and religious duties, encourage them by honorary rewards, pension them off after they have served as many years as their country ought to require: they will love the service; and the arts of our enemies will be as unavailing as their arms. For the surplus of an army, when war shall be at an end, there is indeed no such immediate employment as would be offered for our seamen; but the same means which would, above all others, tend to promote the power and security of Great Britain, would provide an outlet for this redundance also.

The subject of foreign trade puts me in mind of the following strange Jeu d'esprit of the late Professor Porson.

THE DEVIL'S WALK.

From his brimstone bed at the break of day,
A walking the Devil has gone;
To visit his snug little farm of the earth,
And see how his stock goes on.

And over the hill, and over the dale,
And he rambled over the plain:
And backward and forward he switcht his long tail,
As a gentleman switches his cane.

And I pry'thee friend, how was the Devil drest?
Oh! he was in his Sunday's best:
His coat was red, his breeches were blue,
With a hole behind which his tail went through.

He saw a lawyer killing a viper
On a dunghill near his own stable;
And the Devil was tickled, for it put him in mind
Of Cain and his brother Abel.

He saw an apothecary on a white horse
 Ride by, on his vocation;
And the Devil was pleased, for he thought he beheld
 His friend DEATH in the Revelation.

He saw a cottage with a double coach house,
 A cottage of gentility:
And the Devil he smil'd, for his darling vice
 Is pride which apes humility.

He went into a rich bookseller's shop;
 Says he "we're both of one college;
"For I myself sat, like a cormorant once
 "Hard by the tree of knowledge."

As he pass'd through Cold-bath fields, he saw
 A solitary cell:
And the Devil he paus'd, for it gave him a hint
 For improving the prisons of hell.

Down a river did glide with wind and tide
 A pig with vast celerity;
And the Devil he grinn'd, for he saw all the while
How it cut its own throat, and he thought with a smile
 On England's commercial prosperity!

He saw general Gascoigne's burning face,
 Which fill'd him with consternation;
And back to hell his way he did make,
For the Devil he thought (by a slight mistake)
 'Twas the *general conflagration!*

PORSON had imbibed the common, indiscriminate, and therefore silly prejudice, entertained in England against law and lawyers. Luckily for that country, he had no opportunity of witnessing what great things might be done, by making every man his own lawyer, every tavern a court of justice, and investing every citizen of the state, with the qualifications of a lord Mansfield by an act of the legislature. Porson knew nothing of arbitration laws, arbitration courts, arbitration decisions, and arbitration costs; nor of the convenience of bringing justice home to every man's door; that is to the nearest tipling house. He did not know with what peculiar felicity, the lawyers of this country are denominated gentlemen of the *bar!*

He had seen something of the presumptuous and daring despotism of a party in power, in England—but he had not witnessed the republican improvements introduced by the legislative judges here, on the paramount and convenient principle of DISPATCH. Those who have witnessed such things, will excuse many of the evils attendant on the legal system of their own country; and view with patience at least, if not with respect, the calumniated forms of legal proceedings, which expedience and experience must have had so large a share in establishing. All good has its attendant evil; and doubtless, time will point out gradually, the best remedies for such evils as are remediable. But ignorance, is a presumptuous, impatient, headlong reformer. Ignorance sees no difficulties; takes no pains to amalgamate the future with the past; or to join with the dexterity of a master-hand, the new to the old. Reformation, ought to bear upon his front, the motto, *Festina lente.*

NOTICE.

I have said, that six owners of furnaces in Manchester, were fined 1[illegible] pounds sterling each for not consuming the smoke of their fires, in the year 1796: the year is a mistake; but the fact is so; and there is a short report of the case in the Monthly Magazine, Vol. XII. page 76. It happened in August 1801, and instead of six, eleven were so fined.

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STEAM ENGINE.

Continued.

I PROCEED now to give an account of the improvements, or supposed improvements, that have been suggested subsequent to the patent of Mr. Watt, of Birmingham.

In so doing, I shall confine myself to the statement of facts. Whatever my own opinion may be, I feel the absence of twenty years practical knowledge, too strongly, to conceive my opinions entitled to any weight: if it were otherwise, the fairest and most satisfactory course for me to pursue, is to give information from which others may make up their minds on any preference which different plans may be entitled. I shall present, as faithfully as I can, all the useful knowledge on this subject, that the compass of this publication will enable me to furnish. My own actual experience, extends no farther than an eight hour engine of Watt's construction, which for about two years was under my own management. Whatever else I may know, I derive from the same sources I present to my reader.

I make these observations, in reply to some letters on the subject, which require to be thus noticed.

The plan of this work will not permit me to insert plates of *all* the steam engines subsequent to Watt's. I wish it would. The subject is of great importance. James Watt, of Birmingham, would have been cheaply purchased by England at the price of *twenty millions sterling.* I foresee the time when *civil engineers* will be rising up among us. To such persons this paper will be of use. But though I cannot insert *every thing* I wish to see on the subject of steam engines, I shall insert every thing that appears to me of chief importance in the way of improvement, so that this essay shall not leave any *principle* unknown. In the present essay, and in the references I am now about to give, *every thing* material to be known respecting steam engines, either in theory or in practice, so far as it is contained in English or French publications, may be found. I much wish the whole was published together in a separate volume.

Architecture hydraulique par M. Prony, 2 vols. qto.

Repertory of Arts, old series.

Hornblower's engine with pl.	IV. 361. IX. 290. and N. S. VII. 81.
Cartwright's	X. and XIV. 362. and 1 Phil. Mag. 1
Robertson's	XVI. 364.

New series.

Boaz's engine with plate	VIII. 321.
Trevethick's	IV. 241.
Rider's	VII. 258.
Murdoch's	XIII. 11.
Woolf's	VI. 4. VIII. 86.
Deverill's	VIII. 81.
On the force of Steam	I. 22.

T. C.

Specification of the patent granted to Mr. Jonathan Hornblower, *of Penryn, in the county of Cornwall, plumber and brasier; for his invention of a machine or engine for raising water, or other liquids, and for other purposes, by means of fire and steam.*

Dated July 13, 1781.—Term expired, 1795.

TO all to whom these presents shall come, &c. NOW KNOW YE, that, in compliance with the said proviso, and in pursuance of the said statute, I, the said Jonathan Hornblower, do hereby declare, that my said invention is described in manner and form following: that is to say, first, I use two vessels in which the steam is to act, and which, in other steam engines, are generally called cylinders. Secondly, I employ the steam, after it has acted in the first vessel, to operate a second time in the other, by permitting it to expand itself, which I do by connecting the vessels together, and forming proper channels and apertures, whereby the steam shall occasionally go in and out of the said vessels. Thirdly, I condense the steam, by causing it to pass in contact with metalline surfaces, while water is applied to the opposite side. Fourthly, to discharge the engine of the water used to condense the steam, I suspend a column of water in a tube or vessel constructed for that purpose on the principles of the barometer; the upper end having open communication with the steam-vessels, and the lower end being immersed into a vessel of water. Fifthly, to discharge the air which enters the steam vessels with the condensing water, or otherwise, I introduce it into a separate vessel, whence it is protruded by the admission of steam. Sixthly, that the condensed vapour shall not remain in the steam vessel, in which the steam is condensed, I collect it into another vessel, which has open communication with the steam vessels, and the water in the mine, reservoir, or river. Lastly, in cases where the atmosphere is to be

employed to act on the piston, I use a piston so constructed as to admit steam round its periphery, and in contact with the sides of the steam vessel, thereby to prevent the external air from passing in between the piston and the sides of the steam vessel. In witness whereof, &c.*

I give no account of Mr. Trevethick's engine, where the depressing force on the piston is a column of water, because this does not come under the description of a steam engine. An account of this engine may be found in 1 Nich. Jour. 8vo. Series 161. But it appears that Mr. Trevethick erected steam engines that worked without condensing the steam. The following account is sufficient to render them unpopular, though perhaps unjustly.

Dreadful accident. On Thursday the 8th of Steptember, a steam engine employed to assist in clearing the works from water at the tide-mills now erecting in the marsh between Greenwich and Woolwich, was blown up by the force of the contained steam. The explosion was as sudden and dreadful as that of a powder-mill, and was accompanied with a similar noise, which was heard at a great distance from the place. The engine was on Mr. Trevethick's plan, worked by the expansive force of steam only, without employing condensation as in the engines in common use. It was literally blown to pieces; and we are sorry to state, that by the accident three people were killed on the spot, and three others, all that were there at the time, so much hurt that two of them are not expected to recover. It was a fortunate circumstance that the accident happened at a time when the other workmen were at dinner, or a much greater number might have lost their lives.

* This patent seems to me to forestall, in some degree, the improvement of Mr. Woolf, in working his steam twice over. I am unable to say, whether this patent has been in much demand.

T. C.

Steam engines on Mr. Trevethick's plan require a boiler of immense strength; for they work with a power sometimes equal to 60 pounds on the square inch, while common engines, even Mr. Watt's, seldom work with more than 5 pounds. We are happy to state, however, that the present accident arose, not from the impossibility of making a boiler strong enough, but from a culpable mismanagement of a boy appointed to attend the engine. Impatient to finish his work, he had put a piece of timber between the top of the safety valve and a beam above it, so that it could not rise to allow steam to escape when produced in greater quantity than required. He even went away to fish in the river. In the mean time the engine was stopped by another workman, who knew not what the boy had done, and in a short time the mischief we have stated followed. The boy had returned, and was in the very act of removing the piece of wood he had so imprudently put over the valve when the explosion took place. He was the least hurt of all who were near the spot.

This accident ought to serve as a warning to engineers, to construct their safety valves in such a manner that common workmen cannot stop them at their pleasure; which may be easily done.

From the way in which part of the boiler was bent, which was constructed of cast iron nearly an inch in thickness, it is thought the steam must have acquired an expansive force equal to 500 pounds on the square inch before it gave way—a force much beyond any that can be required. But though this shows that engines on Mr. Trevethick's plan, may, with proper precautions, be worked with as much safety as those on the common principle, such an accident as the one we have stated cannot fail to intimidate some people from adopting them. It is therefore with much pleasure we state that a boiler on a new construction, calculated to bear a much higher de-

gree of expansive force than can ever in any case be required, has been lately invented by a very able engineer, Mr. Woolf. It consists of a combination of cylindrical tubes, which unite the double advantage of exposing a much larger surface to the action of the fire than the common boiler, while they possess a much greater degree of strength. This invention appears to us so important, that we shall take an early opportunity of laying a description of it before the public.

The latest and most important improvements are contained in Mr. Woolf's patent for his steam engine.

A short Account of Mr. Arthur Woolf's *improvement in the Construction of Steam Engines.*

Mr. Woolf founds his improvements on a very important discovery which he has made respecting the expansibility of steam when increased in temperature beyond the boiling point, or 212° of Fahrenheit's thermometer. It has been known for some time, and for this discovery the world is indebted to Mr. Watt, who has been the principal improver of the steam engine, that steam acting with the expansive force of four pounds the square inch against a safety-valve exposed to the atmosphere, is capable of expanding itself to four times the volume it then occupies, and still to be equal to the pressure of the atmosphere. Mr. Woolf has discovered that, in like manner, steam of the force of five pounds the square inch can expand itself to five times its volume; that masses or quantities of steam of the like expansive force of six, seven, eight, nine, or ten pounds the square inch, can expand to six, seven, eight, nine, or ten times their volume, and still be respectively equal to the atmosphere, or capable of producing a sufficient action against the piston of a steam engine to cause the same to rise in the old engine (with a counterpoise) of Newcomen, or to be carried into the vacuous

part of the cylinder in the improved engines first brought into effect by Messrs. Boulton and Watt; that this ratio is progressive, and nearly if not entirely uniform, so that steam of the expansive force of 20, 30, 40, or 50 pounds the square inch of a common safety-valve will expand itself to 20, 30, 40, or 50 times its volume; and that, generally, as to all the intermediate or higher degrees of elastic force, the number of times which steam of any temperature and force can expand itself, is nearly the same as the number of pounds it is able to sustain on a square inch exposed to the common atmospheric pressure: provided always that the space, place, or vessel in which it is allowed to expand itself, be of the same temperature as that of the steam before it be allowed room to expand.

Respecting the different degrees of temperature required to bring steam to, and maintain it at, different expansive forces above the weight of the atmosphere, Mr. Woolf has found, by actual experiment, setting out from the boiling point of water, or 212°, at which degree steam of water is only equal to the pressure of the atmosphere, that in order to give it an increased elastic force equal to five pounds the square inch, the temperature must be raised to about $227\frac{1}{2}$°, when it will have acquired a power to expand itself to five times its volume, still be equal to the atmosphere, and capable of being applied as such in the working of steam engines, according to his invention: and with regard to various other pressures, temperatures, and expansive forces of steam, the same are shown in the table which he has inserted in the following specification:

Specification of the Patent granted to Arthur Woolf, *of Spa Fields, in the County of Middlesex, for certain Improvements in the Construction of Steam-Engines. Dated June* 7, 1804.

To all to whom these presents shall come, &c. Now know ye, that in compliance with the said proviso, I the

said Arthur Woolf, do hereby describe and ascertain the nature of my said invention, and the manner in which the same is to be performed, as follows: that is to say, I have ascertained, by actual experiments, and have applied the same to practice, that as in practice it is found that steam acting with the expansive force of four pounds the square inch, against a safety-valve exposed to the atmosphere, is capable of expanding itself to four times the volume it then occupies, and still to be equal to the pressure of the atmosphere; so in like manner steam of the force of five pounds the square inch can expand itself to five times its volume. Masses or quantities of steam of the like expansive force of six, seven, eight, nine, or ten pounds the square inch, can expand itself to six, seven, eight, nine, or ten times its volume, and still be respectively equal to the atmosphere, or capable of producing sufficient action against the piston of a steam-engine, to cause the same to rise in the old engine (with a counterpoise) of Newcomen, or to be carried into the vacuous part of the cylinder in the improved engines first brought into effect by Boulton and Watt: and this ratio is progressive, and nearly, if not entirely, uniform; so that steam of the expansive force of twenty, thirty, forty, or fifty pounds the square inch of a common fafety-valve, will expand itself to twenty, thirty, forty, or fifty times its volume; and, generally, as to all the intermediate or higher degrees of elastic force, the number of times which steam of any temperature and force can expand itself, is nearly the same as the number of pounds it is able to sustain on a square inch, exposed to the common atmospheric pressure; provided always, that the space, place or vessel, in which it is allowed to expand itself, be at least of as high a temperature, or nearly as high a temperature, as that of the steam before it be allowed room to expand: that is, whatever be the degree of heat necessary to the permanency of steam of the force

of twenty pounds the square inch, if steam of that force be employed, the space, place, or vessel in which it is allowed or intended to expand itself, should be of the same temperature, or nearly so; and so with steam of any other power, as of thirty, forty, or fifty pounds the square inch, the space, place, or vessel in which it is to expand, should be at or about the same degree of heat as steam of the force employed requires for its existence; in which case, as I have before stated, steam can expand itself about as many times as the number of pounds it could have sustained on a square inch as aforesaid, before it is allowed to expand or dilate itself. Here, however, it may be necessary to remark, that in stating this ratio, I only speak of the expansion of steam as it can be managed and commanded in practice, and not of the absolute expansion which perhaps might be obtained, if mechanism could be made so perfect as to prevent all escape of steam, and all partial condensation of it and waste of heat; for the real expansive force of steam, I am inclined to believe, from the experiments I have made, increases in a regular ratio a little beyond what I have stated, though I would not recommend that it should be calculated higher in applying it to steam-engines, because the difficulty of confining and managing it increases also as the elasticity of the steam is increased, or as its temperature is increased.

And here it may be of use to the public to state some facts respecting different degrees of temperature required to bring steam to, and maintain it at, different expansive forces above the weight of the atmosphere; because the temperature of the steam indicated by a thermometer, having its bulb in the boiler which produces it, will indicate the expansive force of the steam, without the trouble and inconvenience of changing the weights on the valve, by which its force is regulated for the work intended to be performed by it, and which valve acts as a common

safety-valve, so that those who attend the boiler will know with sufficient precision, by looking at the thermometer, how they ought to feed the fire; and, moreover, the relation between the temperature and the expansive force being known, the danger of accidents from the safety-valve becoming deranged will be lessened, for the workman will naturally be led to notice whether the safety-valve acts freely when the thermometer has risen to the degree that answers to the weight with which the valve is loaded for working. I have found by actual experiment, setting out from the boiling point, or two hundred and twelve degrees of the thermometer, commonly employed in this country, which is that of Fahrenheit, at which degree steam of water is only equal to the pressure of the atmosphere, that in order to give it an increased elastic force equal to five pounds the square inch, the temperature must be raised fifteen or sixteen degrees, or to about two hundred and twenty-seven and a half, when the steam will have acquired a power to expand itself to five times its volume, and still be equal to the atmosphere, and capable of being applied as such in the working of steam engines according to my said invention. And with regard to various other pressures, temperatures, and expansive forces of steam, the same are shown in the following table:

Table of the relative pressures per square inch, temperatures and expansibility of steam at degrees of heat above the boiling point of water, beginning with the temperature of steam of an elastic force equal to five pounds per square inch, and extending to steam able to sustain forty pounds on the square inch.

	Pounds per square Inch.		Degrees of Heat.		Expansibility.	
Steam of an elastic force predominating over the pressure of the atmosphere upon a safety valve,	5	requires to be maintained by a temperature equal to about	227½	and at these respective degrees of heat, steam can expand itself to about	5	times its volume, and continue equal in elasticity to the pressure of the atmosphere.
	6		230¼		6	
	7		232¾		7	
	8		235¼		8	
	9		237½		9	
	10		239½		10	
	15		250¼		15	
	20		259½		20	
	25		267		25	
	30		273		30	
	35		278		35	
	40		282		40	

And so in like manner, by small additions of temperature, an expansive power may be given to steam to enable it to expand to fifty, sixty, seventy, eighty, ninety, one hundred, two hundred, three hundred, or more times its volume, without any limitation but what is imposed by the frangible nature of every material of which boilers or other parts of steam engines have been or can be made; and prudence dictates that the expansive force should never be carried to the utmost the materials can bear, but rather be kept considerably within that limit.

Having thus fully explained my discovery of the expansive power and force of steam, I shall proceed to describe my improvements grounded thereon; and in so doing, I shall find it necessary to mention the entire steam engine, and its parts, to which, as an invention well known, I neither can nor do assert any exclusive claim; but at the same time I must here observe, that, from the nature of my said discovery, and its application, there can

be no difficulty in distinguishing my said improvements from the improved engine, as to its other common and well known component parts.

1st. If the engine be constructed originally with the intention of adopting my said improvements, it ought to have two steam vessels of different dimensions, according to the temperature or the expansive force determined to be communicated to the steam made use of in working the engine; for the smaller steam vessel, or cylinder, must be a measure for the larger. For example, if steam of forty pounds the square inch is fixed on, then the smaller steam vessel should be at least one-fortieth part the contents of the larger one. Each steam vessel should be furnished with a piston, and the smaller cylinder should have a communication both at its top and bottom (top and bottom being here employed merely as relative terms, for the cylinders may be worked in a horizontal, or any other required position, as well as vertical.) The small cylinder, I say, should have a communication both at its top and bottom with the boiler which supplies the steam; which communications, by means of cocks or valves of any construction adapted to the use, are to be alternately opened and shut during the working of the engine. The top of the small cylinder should have a communication with the bottom of the larger cylinder, and the bottom of the smaller one with the top of the larger, with proper means to open and shut these alternately by cocks, valves, or any other well known contrivance. And both the top and bottom of the larger cylinder or steam vessel should, while the engine is at work, communicate alternately with a condensing vessel, into which a jet of water is admitted to hasten the condensation; or the condensing vessel may be cooled by any other means calculated to produce that effect. Things being thus arranged, when the engine is at work, steam of high temperature is admitted

from the boiler, to act by its elastic force on one side of the smaller piston, while the steam which had last moved it has a communication with the larger steam vessel or cylinder, where it follows the larger piston, now moving towards that end of its cylinder which is open to the condensing vessel. Let both pistons end their stroke at one time, and let us now suppose them both at the top of their respective cylinders, ready to descend; then the steam of forty pounds the square inch entering above the smaller piston will carry it downwards, while the steam below it, instead of being allowed to escape into the atmosphere, or applied to any other purpose, will pass into the larger cylinder above its piston, which will take its downward stroke at the same time that the piston of the smaller cylinder is doing the same thing; and while this goes on, the steam which last filled the larger cylinder in the upward stroke of the engine will be passed into the condenser, to be condensed during the downward stroke. When the pistons in the smaller and larger cylinder have thus been made to descend to the bottom of their respective cylinders, then the steam from the boiler is to be shut off from the top, and admitted to the bottom of the smaller cylinder, and the communication between the bottom of the smaller and the top of the larger cylinder is also to be cut off, and the communication to be opened between the top of the smaller and the bottom of the larger cylinder; the steam, which in the downward stroke of the engine filled the larger cylinder, being now open to the condenser, and the communication between the bottom of the larger cylinder and the condenser shut off; and so alternately admitting the steam to the different sides of the smaller piston, while the steam last admitted into the smaller cylinder passes alternately to the different sides of the larger piston in the larger cylinder, the top and bottom of which are made to communicate alternately with

the condenser. In an engine working with the improvements which have been just described, while the steam is admitted to one side of the piston in the smaller cylinder, the steam on the other side has room made for its admission into the larger cylinder on one side of its piston, by the condensation going on on the other side of the large piston which is open to the condenser; and that waste of steam which takes place in engines worked only by the expansive force of steam, from steam passing the piston, is prevented; for all steam that passes the piston in the smaller cylinder is received into the larger. In such an engine, where it may be more convenient for any particular purpose, the arrangement may be altered, and the top of the smaller made to communicate with the top of the larger, and the bottom of the smaller with the bottom of the larger cylinder; in which case the only difference will be, that when the piston in the smaller cylinder descends that in the larger will ascend, and while the latter descends the former will ascend; which for some particular purposes may be more convenient than the arrangement before described.

2dly. As the difficulty of giving a proper degree of strength to large cylinders, and the cases for the same, which are to be exposed to the action of strong steam, increases in proportion as their size is augmented; instead of employing, besides the smaller cylinder or steam measure, one cylinder only of large diameter in steam engines of great power, I sometimes prefer substituting for the latter cylinder two or more cylinders of smaller diameter, but of such dimensions that their capacity, and the area of the pistons worked in them, are equal to the area of the one piston, and the capacity of the one cylinder which otherwise would be necessary; and such substituted cylinders are made to communicate with each other, that they may at one and the same time receive and part with

the steam by which the engine is worked; and their respective piston rods are so connected with one another, or with other parts of the machinery, that the pistons may act together.

3dly. With regard to steam engines which are already constructed, I improve the same by adding thereto a small cylinder or measure for the steam admitted to the working cylinder; this improvement may be introduced with great advantage into the steam engines constructed according to Mr. Watt's improvements; which small cylinder may be either employed only as a measure of the steam, or a piston may be worked in it by the expansive force of the steam, before it be allowed to pass into the present working cylinder or steam vessel, which in that case must have no direct communication with the boiler, but must be supplied with steam through the medium of the small added cylinder or steam measure. To make this more intelligible, suppose the steam measure or small cylinder added to one of Mr. Watt's single engines, or to one of similar construction, and that the small added cylinder is furnished with a piston to work by the expansive force of the steam, while the larger cylinder works by condensation; then all that is necessary is, that the top of the smaller added cylinder be connected with the boiler, and furnished with a cock or valve to shut off the steam, and that the boiler be of sufficient strength: let a pipe pass from the top to the bottom of the smaller added cylinder, furnished with a cock or valve, by which a communication may be made between the two sides of the piston in the said cylinder; let a pipe also pass from the bottom of the smaller cylinder to the top of the larger; let the larger cylinder, as is now commonly the case in practice, have a pipe passing from its top to its bottom, by which a communication can be made between the two sides of the piston in the large cylinder; and let the large cylinder

communicate with a condensing vessel, with valves, cocks, or any other contrivance to open or shut the different communications when necessary. Things being thus arranged, suppose the engine at work, and the pistons in both cylinders at the top of their respective cylinders, and suppose the steam admitted to enter the small cylinder above the piston; while the steam is thus entering, let the communication between the bottom of the small cylinder and the top of the large one be open, while the bottom of the large one is open to the condenser; then both pistons will descend. When they have reached the bottom of their respective cylinders, the communications between the boiler and the small cylinder, between the small cylinder and large cylinder, and between the latter and the condenser, must all be shut off; and the communications must be opened between the two sides of the smaller piston and between the two sides of the larger piston: then, as the pistons ascend, the steam which was last admitted above the small piston will pass to its under side, while the steam which was last admitted to the top of the large from the lower part of the small cylinder will pass into the lower part of the large cylinder under its piston, and both pistons will at the same time ascend by the action of the counter-weight, or the momentum of the fly, as the case may be. When both pistons have reached the top of their respective cylinders, the last mentioned communications are shut, and the others are opened as before, and both will descend; the steam which was last admitted to the under side of the small piston passing into the upper end of the large cylinder, while the steam last introduced below the piston of the large cylinder goes off to the condenser. Or an arrangement similar to the following may be adopted: Let only the bottom part of the smaller cylinder have a communication with the boiler, and let there be also a communication between the bottom

of the smaller and the top of the larger cylinder, and another communication between the top part of both cylinders which last mentioned communication always remains open; and let the top and bottom of the large cylinder also communicate by means of a side pipe; and let the bottom part of the large cylinder communicate with a condenser. Things being thus arranged, when steam is admitting into the lower part of the smaller cylinder, the piston in that cylinder will ascend; the communication between the top of the two cylinders being then open, to allow the steam above the smaller piston to pass into the top of the larger, where it is not to be detained, but, along with the steam above the piston in the large cylinder, to be allowed to pass under the last mentioned piston (which is now ascending as well as the piston in the smaller cylinder), the communication between the two sides of the large piston being now open, and the communication with the condenser shut off. Both pistons having reached the top of their respective cylinders, the communications which before were open must now be shut (excepting the communication between the two cylinders at their upper part) and the communications between the bottom of the small and the top of the large, and between the bottom of the large and the condenser, must be opened: the steam last admitted into the lower part of the smaller cylinder will now ascend into the top of the larger and expand itself, following the piston of the larger cylinder which is now descending, its other side being open to the condenser; and (as the tops of the two cylinders communicate) steam will also pass into the top of the smaller cylinder above its piston, so that both pistons descend together to the bottom of their respective cylinders; when a fresh charge of steam is again to be admitted for a fresh stroke of the engine.

4thly. If my improvements be applied to one of the engines known by the name of Watt's double engine, the working cylinder must have no direct communication with the boiler, but must be made to communicate at its top and bottom alternately with the lower and upper part of the smaller added cylinder, or simply, as the case may be, at its top and bottom, with the steam measure, which has a direct communication with the boiler; the effect of which must be sufficiently obvious from the details I have already given respecting the nature of my invention, and the way in which the same is to be carried into actual practice.

5thly. With regard to steam engines, in which the separate steam measure may not be thought advisable, the same may be improved by the application of my aforesaid discovery, by making the boiler, and the steam case or cases in which the working cylinder or cylinders is or are inclosed, much stronger than usual; and by altering the structure and dimensions of the cocks, valves, slides, or other means of admitting steam from the boiler into the cylinder or cylinders, in such a manner as that the steam may be admitted very gradually by a progressive enlargement of the aperture, so as at first to wiredraw, and afterwards admit more freely the same. The reason for this precaution is this: Steam of such great elastic force as I employ, if admitted suddenly into the cylinder or cylinders, when more than one working cylinder is employed, would strike with a force that would endanger the safety and durability of the engine. The aperture allowed to the valve, cock, or other contrivance for admitting steam into the cylinder or cylinders, should be regulated by the following consideration:—If the intention is that the engine should work only, or almost wholly, by condensation, the steam in passing into the cylinder or cylinders should be forced to wiredraw itself, as I have already said, but so

that the piston or pistons may perform the whole or a great part of the stroke by the time the intended quantity of steam has been admitted into the cylinder or cylinders: for example, when steam of forty pounds the square inch is used, such a quantity of the same as shall be equal in volume to one-fortieth of the capacity of the cylinder or cylinders, and so in proportion when steam of any other force is employed; and when the requisite quantity has been admitted, the steam is to be shut off till the proper moment for admitting a fresh quantity. But if it is intended that advantage shall also be taken of the elastic force of the steam acting on one side of the piston or pistons, while condensation goes on on the other side, then the steam must be admitted more freely, but still with caution at the first, for the reason already mentioned. And in this, as well as in every other application of my said improvements, grounded on my said discovery of the law of expansibility of steam, due and effectual means must be used to keep up the requisite temperature of all the parts of the apparatus into which the steam is admitted, and in which it is not intended to be condensed. And here it may be proper to state, that, instead of the obvious and usual means for accomplishing this, namely, inclosing them in the boiler, or in a steam case or cases communicating with the boiler, the following method may sometimes be used with advantage, viz. a separate fire under the steam case or cases, which, in that event, will become a boiler or boilers, and must be furnished with a safety-valve or valves to regulate the temperature. By means of the last-mentioned arrangement, the steam from the smaller cylinder or steam measure (when either of these is employed) may be admitted into the larger cylinder or cylinders kept at a higher temperature than the smaller, by which its power to expand itself may be increased; and, on the contrary, by keeping the larger at a

lower temperature than the smaller, its expansibility will be lessened; which, on particular occasions, and for particular purposes, may be desirable. In every case care must be taken that the boiler, the case or cases in which the cylinder or cylinders is or are inclosed, the steam pipes, and generally all the parts exposed to the action of the expansive force of the steam, be of a strength proportioned to the high pressure to which they are to be exposed. With regard to the due degrees of strength of the parts of all my said improvements, together with the nature of the materials, and the proportions of the same, except as herein described, I forbear any further description, on account of the numerous variations to which the same must be subjected; and because every engineer, of sufficient skill to be employed in works of this nature, will, without difficulty, arrange and determine the same according to the nature of the case.

Lastly. I have to observe, that, to avoid unnecessary tautologies in speaking of the proportion that ought to subsist between the smaller cylinder or the steam measure and the larger cylinder, or the quantity of steam to be admitted to the working cylinder, where a separate smaller cylinder or steam measure is not adopted, though I have mentioned the regular proportions, as, for example, of a measure or quantity equal to one-fortieth of the working cylinder when steam of forty pounds the square inch is to be employed, or equal to one-thirtieth, or one-twentieth, when steam of thirty or twenty pounds the square inch is to be used; yet these are not the only proportions that may be used; for, though it may not be advisable that the proportion of the smaller cylinder or steam measure should in any case be made much smaller than I have stated, yet, in making it larger, considerable latitude may be allowed: for example, with steam of forty pounds the square inch, a smaller cylinder or measure of

one-twentieth, or even larger, or of some intermediate proportion, may be employed instead of one of a fortieth of the capacity of the larger or working cylinder; and so with steam of any other given strength. And it may be advisable, that in a number of engines this should be the case, because of the difficulty of preventing some waste of steam or partial condensation which might lessen the rate of working, if not allowed for in the size of the smaller cylinder or steam measure; or in the quantity of steam admitted directly from the boiler into the working cylinder, where no smaller cylinder or steam measure is employed: and in every case the engine, when got ready for work, whatever may be the proportion that has been adopted as intended to be worked with, should have its power tried, by altering the load on the valve that ascertains the force of the steam, in order that the strength of steam best adapted for the engine may be ascertained; for it may turn out to be advantageous that the steam should be employed, in particular engines of an elastic force, somewhat over or under what was first intended.

In witness whereof, &c.

Since that Mr. Woolf has made other improvements of which the following is a brief view taken from Vol. 23, p. 123, of Tilloch's Mag.

Account of Mr. ARTHUR WOOLF'S *new Improvements on Steam-Engines.*

In our nineteenth volume, p. 133, we gave a short account of a former improvement made by Mr. Woolf on the steam-engine, founded on a discovery that steam, of any higher temperature than that of boiling water, if allowed to pass into another vessel kept at the same temperature as the steam itself, will expand to as many times its volume, and still be equal to the pressure of the common atmosphere, as the number of pounds which such steam,

before being allowed to expand, could maintain on each square inch of a safety-valve exposed to the atmosphere: for example, that masses or quantities of steam of the expansive force of 20, 30, or 50 pounds the square inch of a common safety-valve, will expand to 20, 30, or 50 times its volume, and still be respectively equal to the atmosphere, or capable of producing a sufficient action against the piston of a steam-engine to cause the same to rise in the old engine (with a counterpoise) of Newcomen, or to be carried into the vacuous part of the cylinder in the improved engines first brought into effect by Messrs. Boulton and Watt.

In consequence of this discovery Mr. Woolf was enabled to use his steam twice (if he chose), and with complete effect; nothing more being necessary than to admit high steam, suppose of 40 pounds the square inch, into one cylinder, to work there by its expansive force, and then to allow the same steam to pass into, and expand itself in, another cylinder of forty times the size of the first, there to work by condensation in the common way. Or with only one cylinder, by admitting a proportionally small quantity of high steam into it from the boiler, Mr. Woolf found that he could effect a considerable saving in fuel.

In this first improvement of Mr. Woolf, though the saving might be carried a considerable length, it was still necessarily limited by the strength of materials; for in the employment of high steam there must always be some danger of an explosion. Mr. Woolf, however, by a happy thought, has completely obviated every danger of this kind, and can now take the full advantage of the expansive principle without the least danger whatever. This he effects by throwing into common steam the additional temperature necessary for its high expansion, *after the steam is admitted into the working cylinder*, which is heated by means adequate to the end intended to be obtained;

and the advantage which he thus gains he effectually secures by a most ingenious improvement in the piston. It may be easily conceived that steam of such high rarity as Mr. Woolf employs, could not be made fully effective with the piston in common use; for in proportion to its rarity so must be the facility with which a portion of it would escape, and pass by the side of the piston to the vacuous part of the cylinder: but Mr. Woolf's contrivance seems perfectly adapted to prevent the loss of even the smallest portion of the steam.

Besides these improvements on the common steam-engine, he has also found means to apply the same principles to the old engine, known by the name of Savary's, in such a way as to render the same a powerful and economical engine for a great variety of purposes.

Such is the outline of Mr. Woolf's improvements on this most useful engine: but, for the general information of practical engineers, we shall here subjoin a more technical description, in Mr. Woolf's own words, extracted from his specification of his patent.

"I have found out and invented a contrivance, by which the temperature of the steam vessel or working cylinder of a steam-engine, or of the steam vessels or cylinders where more than one are used, may be raised to any required temperature, without admitting steam from the boiler into any surrounding receptacle, whether known by the name of a steam case, or by any other denomination. That is to say, instead of admitting steam of a high temperature into such receptacle or steam case, which is always attended with a risk of explosion proportioned to the elasticity of the steam employed, I put into the said surrounding receptacle, or case, oil or the fat of animals, or wax, or other substances capable of being melted by a lower temperature than the heat intended to be employed, and of bearing that heat without being convert-

ed into vapour: or I put into the said case or cases mercury or mixtures* of metals, as of tin, bismuth, and lead, capable of being kept in a state of fusion in a lower temperature than that intended to be employed in working the steam-engine; and I so form the surrounding case or cases as to make it or them admit the aforesaid oil, or other substance employed, to come into contact not only with the sides of the steam vessel or vessels, or working cylinder or cylinders, but also with the bottom and top of the same, so that the whole may be as much as possible maintained at one uniform temperature; and this temperature I keep up by a fire immediately under or round the case or cases that contains the aforesaid oil or other substance, or by connecting the said case or cases with a separate vessel or vessels kept at a proper temperature, filled with the oil or other substance made use of as aforesaid. In some circumstances, or whenever the same may be convenient or desirable, I employ the fluid metals, or mixtures of metals, and oil or other of the substances before enumerated, at one and the same time in the same engine: that is to say, in the part of the case or vessel exposed to the greatest action of the fire, I sometimes have the aforesaid metals or mixtures of metals, and in the parts less exposed to the action of the fire, I put oil, or other substances capable of bearing the requisite heat without being converted into vapour.

" By this arrangement, and method of applying the surrounding heat, I not only obviate the necessity of employing steam of a great expansive force round the steam vessel or vessels, or the working cylinder or cylinders, as already mentioned, to maintain them at the temperature required, but I am enabled to obtain from steam of a comparatively low temperature, or even from water itself ad-

* Chancellor Livingston suggested this idea many years ago to Dr. Priestley. T. C.

mitted into the steam vessel or vessels, all the effects that can be obtained from steam of a high temperature, without any of the risk with which the production of the latter is accompanied, not only to the boiler and other parts of the machinery, but even to the lives of the workmen; for such low steam, or even water, (but in every case steam is preferable,) being admitted into a steam vessel or vessels, or working cylinder or cylinders, kept at the requisite higher temperature by the forementioned means, will there be expanded in any ratio required, and produce an effect in the working of the engine which cannot otherwise be obtained but at a greater expense of fuel, or with the risk of an explosion. By this means I can make use of steam expanded in any required ratio, or of any given temperature, without the necessity of ever having the steam of any greater elasticity than equal to the pressure of the common atmosphere.

"Another improvement which I make use of in steam engines consists in a method of preventing, as much as possible, the passage of any of the steam from that side of the piston which is acted upon by the said steam to the other side which is open to the condenser; and this I effect, in those steam engines known by the name of double engines, by employing upon or above the piston mercury or fluid metal, or metals in an altitude equal to the pressure of the steam. The efficacy of this arrangement will appear obvious, from attending to what must take place in working such a piston. When the piston is ascending, that is, when the steam is admitted below the piston, the space on its other side being open to the condenser, the steam endeavouring to pass up by the side of the piston is met and effectually prevented by the column of metal equal or superior to it in pressure, and during the down stroke no steam can possibly pass without first forcing all the metal through. In working what

is called a single engine, a less considerable altitude of metal is required, because the steam always acts on the upper side of the piston. For single engines, oil, or wax, or fat of animals, or similar substances, in sufficient quantity, will answer the purpose, if another improvement, which constitutes part of my said invention, be applied to the engine, namely, to take care that either in the double or single engine so to be worked, the outlet that conveys the steam to the condenser shall be so posited, and of such a size, that the steam may pass without forcing before it or carrying with it any of the metal or other substance employed, that may have passed by the piston; taking care at the same time to provide another exit for the metal or other substance collected at the bottom of the steam vessel or working cylinder to convey the same into a reservoir kept at a proper heat, whence it is to be conveyed to the upper side of the piston by a small pump worked by the engine or by any other contrivance. In order that the fluid metal or metals used with the piston may not be oxidated, I always keep some oil or other fluid substance on its surface, to prevent its coming in contact with the atmosphere and to prevent the necessity of employing a large quantity of fluid metal, I generally make my piston of the depth of the column required, but of a diameter a little less than the steam vessel or working cylinder, excepting where the packing or other fitting is necessary to be applied; so that, in fact, the column of fluid metal forms only a thin body round the piston. In some cases I make a hollow metallic piston, and apply an altitude fluid of metal in the inside of the same, to press its outside into contact with the steam vessel or working cylinder.

"It may be necessary, however, to state, that in applying my improved method of keeping the steam vessels of steam engines at any required temperature to the engine known by the name of Savary's, in any of its improved

forms, in which a separate condenser has been introduced, I sometimes employ oil (or any other substance lighter than water, and capable of being kept fluid in the temperature employed, without being converted into vapour,) in the upper part of the tube or pipe attached to the steam vessel: by which means steam of any temperature may be used without being exposed to the risk of partial condensation by the admission of any colder body into the steam vessel; for the oil, or other substance employed for this purpose, soon acquires the requisite temperature; and to prevent unnecessary escape of heat, I construct of, or line with, an imperfect conductor of heat, that part of the tube or pipe attached to the steam vessel which may not be heated exteriorly. And further, (as is already the practice in some engines, and therefore not exclusively claimed by me,) I cause the water raised by the engine to pass off through another ascending tube than the one attached to the steam vessel, but connected with it at some part lower than the oil or other substance employed in it is ever suffered to descend to in the working of the engine. The improvement which I have just mentioned, of introducing oil into the pipe attached to the steam vessel of such engines, may also be introduced without applying heat externally to the steam vessel; but in this case part of the effect which would otherwise be gained is lost."

Description of a Portable Steam Engine. By Mr. MATHEW MURRAY.

To Mr. NICHOLSON.

SIR,

I take the liberty of handing you the description of a portable steam engine of my construction, which you will have the goodness to insert in your Philosophical Journal. I will just observe it is reduced to the fewest parts that

practical utility will admit, which must necessarily render it of great advantage; as the simplicity of its parts make it nearly impossible to be out of order with a very moderate degree of management. The following description and reference to the plate will explain the nature of this engine.

I am, Sir,

Your much obliged humble servant,

MATHEW MURRAY.

Leeds, May 7th, 1805.

Description of a Portable Steam Engine.—Plate I.

AA. Represents the ground or floor on which the engine stands.

B. Section of a recess made in the ground for the beam O to work in.

C. Iron cistern resting upon the ground or floor covering the recess for the beam.

D. An opening in the floor to admit a boy to oil the centres of the beam.

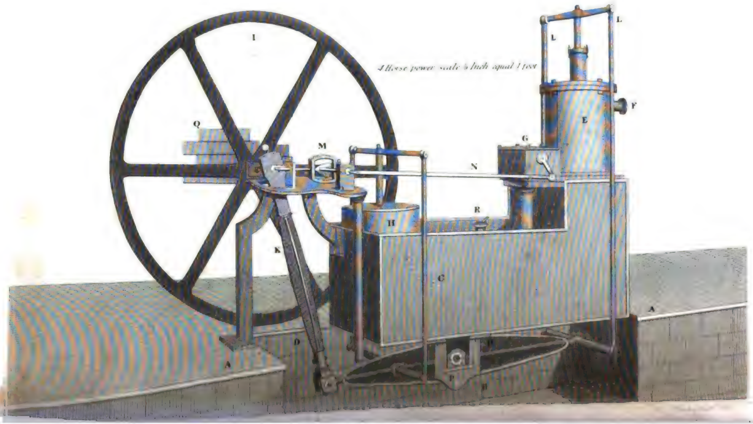
E. A double steam cylinder, having an upright pipe in the intermediate space, which effects a communication between the top and bottom, and the valve box G.

F. A steam pipe that communicates with the boiler through which all the steam passes and surrounds the inner cylinder in its way to the valve box, prior to its application against the piston.

G. The valve box fixed upon a projection from the cylinder bottom, having an opening or connection with the interval between the two cylinders. In this opening is a regulating valve for adjusting the quantity of steam (that acts against the piston) in its passage through the valve box. There are also three other openings in the bottom of this valve box, one of which connects with the top of the cylinder by the pipe in the intermediate space, the second with the bottom, and the third with the educ-

Mr. Murray's portable Steam Engine.

4 Horse power scale ½ Inch equal 1 feet



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tion pipe that leads to the condenser. Two of these openings are alternately connected together by a slide valve,* while the third is left open for the admission of steam to the piston, this valve changes its position at the end of each stroke of the piston, and performs all the purposes of the most complicated machine.

H. The air-pump connected with a condenser at the bottom of the eduction pipe.

I. The fly wheel fixed upon an axis which receives its motion from a crank connected with the beam by the rod K.

LL. Two rods for connecting the motion of the piston to the beam, these rods move perpendicularly by a motion which could not be conveniently shewn in this view without rendering it confused.

M. A spherical triangle turned by the crank for moving the slide valve by the horizontal rod N that connects them together. This motion has the advantage of preventing the engine from ever turning the contrary way round from that which it is wanted to go, and prevents the noise that is usually heard in engines.

O. The beam attached to the bottom of the cistern C by means of the hanging carriages P.

Q. A rest or fixture in a wall for the end of the fly wheel shaft; this will vary according to the situation where the engine is to be fixed, or it may be supported by a metal standard.

R. Index to the injection cock that admits water to the condenser. *Note*, The cistern is to be kept nearly full of water during the time the engine is at work.

The cylinder G and valve box E must be surrounded on all sides by a case, (not shewn in this view) the space between filled with charcoal to prevent the transmission of heat, which if effectually done will work with the least

* For these valves I took out a patent in 1802.

possible quantity of coals, as it combines the advantages of every other engine hitherto known. By detaching the air-pump and condenser (which may be done in half an hour) and where water cannot be had for condensation, this engine may be worked by the pressure of strong steam alone, as the internal cylinder is kept as hot as the steam in the boiler.* This dangerous plan never ought to be resorted to but in cases of necessity, as it is no saving of coals, and as there can be no certain rule when to discontinue the use of the boiler, the weakness of which is not prevented by putting the fire in a tube in the inside of it. This engine requires no framing nor mill-wright work in the fixing, but merely bolting down to the floor it stands upon. It takes up very little room, and all its parts are within reach, without the necessity of upper floors or stages, which would be the case if the beam was above; but by being fixed below and alone, it has no tendency to move from its situation.

Description of a portable Steam-engine, invented by Mr. SAMUEL CLEGG, *David Street, Manchester. Communicated by Mr.* DALTON, *Lecturer at the Royal Institution, &c.*

THIS engine is worked by four copper valves in the usual manner, but the mechanism for lifting them is very different from any hitherto made: there are no levers em-

* Many engines are at present worked in London and elsewhere by the mere force of steam, without condensation, under Trevethick's patent. The force is from 45 to 60 lbs. on the round inch; a pressure equal to about 25 fathoms of water at the most. Various assertions and reports concerning the safety, the economy, and the other effects of these engines have passed under my notice; but the interested situation of some of the narrators on both sides, and the short time of trial, have induced me to wait for more facts before I should give any account of the engine in this Journal. I hope to do this a few months hence.—W. N.

ployed for opening the valves, and there is no hand gear. The steam and exhaustion valves are on the same horizontal plane; those which are vertical to each other are not like those hitherto used, both exposed to the steam or both to a vacuum; but by a simple contrivance in the construction of the nozzles, the one is exposed to the steam while the other has a communication with the condensing vessel. From what has been said it may easily be perceived, if the two valves be connected together by a straight rod, that when this rod is lifted, the pressure is given to the piston, and the machine is put into motion; and if the other two valves be connected in the same manner and lifted at an appointed time, the engine is kept in motion. The outside appearance of these nozzles may be seen at *Fig.* 1. *c c*, (*Plate* II.) The rods which come out of the bottom of the nozzles are kept tight by vertical stuffing-boxes, the whole of which is hid in the drawing by the frame.

The next is a new contrivance for producing a rotative motion from a reciprocating one, which not only simplifies the machine very much, but exceeds the power of the common crank by nearly one-third, in consequence of its acting always perpendicular to the radius of the wheel, which is done by a rock and wheel, as represented by *Fig.* 2 and 3; and as this plan of connection distributes the power uniformly, of course a much lighter fly-wheel is required, which diminishes friction, &c.

Explanation of the Plate.

Fig. 1. is a representation of the engine: one of the corner columns AA, which supports the frame, serves likewise for an eduction-pipe and condensing-vessel: the air-pump E is joined to the condensing vessel by the pipe D'; *e* is the piston rod, and though it works out at the bottom of the cylinder, it is as easily kept tight as if it worked out at the top; *b* is a similar rod which keeps the

rack perpendicular; *a a* are the two radius bars on which the brasses are fixed that support the shaft; by this contrivance the wheel C easily moves from one side to the other of the rack F.

Fig. 2. is a view of the rack on a larger scale, where C represents the wheel and D the shaft; E E, a sliding bar, on which is fixed the small roller *o*, serving as a connecting link to keep the wheel C always in gear; for, when the wheel is in gear on the opposite side of the rack, the roller *o* is on the other side of the plate *a a*; but it will perhaps be more clearly understood by the plan, *Fig.* 3. where the letters represent the same movement as in the elevation, *Fig.* 2: This description may be easily understood by those who already possess a little knowledge of a steam-engine.

Description of a Steam Engine on the Principle of Savary, operating by a separate Condenser; with other essential Improvements. By Mr. John Nancarrow*.

Plate III. Fig. 3. A. The receiver, which may be made either of wood or iron.

BBBB. Wooden or cast-iron pipes for conveying the water to the receiver, and from thence to the penstock.

C. The penstock or cistern.

D. The water-wheel.

E. The boiler, which may be either iron or copper.

F. The hot-well for supplying the boiler with water.

GG. Two cisterns under the level of the water, in which the small bores BB, and the condenser are contained.

HHH. The surface of the water with which the steam engine and water wheel are supplied.

* From a learned paper on Mills, in the American Transactions, IV. page 355. I have not been able to extract the theoretical parts of the paper, because the plates and references are too imperfect.

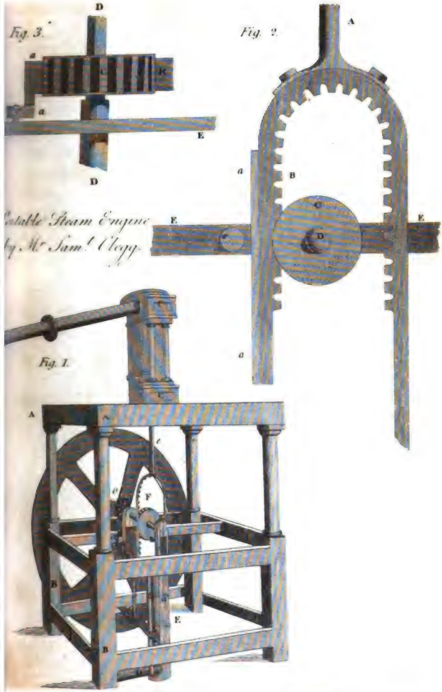


Fig. 3.
D
a
C
B
a
E
D
Fig. 2
A
a
B
C
E
D
E
a
tatable Steam Engine
by Mr Saml Clegg
Fig. 1.
A
A
t
e
F
B
B
E

Tiebout sc.

Mr. John Nancarrow's improved steam engine on Savarys principle, with a separate condenser, &c. &c.

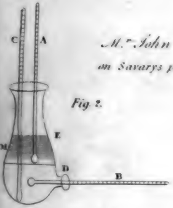
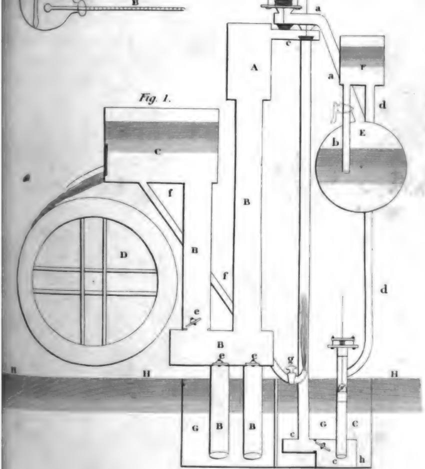


Fig. 2.

Fig. 1.



Tiebout sc.

aa. The steam-pipe, through which the steam is conveyed from the boiler to the receiver.

b. The feeding-pipe, for supplying the boiler with hot water.

ccccc. The condensing apparatus.

dd. The pipe which conveys the hot water from the condenser to the hot-well.

eee. Valves for admitting and excluding the water.

ff. The injection pipe, and *g* the injection cock.

h. The condenser.

It does not appear necessary to say any thing here on the manner in which this machine performs its operations without manual assistance, as the method of opening the cocks by which the steam is admitted into the receiver and condensed, has been already well described by several writers. But it will be necessary to remark that the receiver, penstock, and all the pipes, must be previously filled* before any water can be delivered on the wheel, and when the steam in the boiler has acquired a sufficient strength, the valve at *c* is opened, and the steam immediately rushes from the boiler at E into the receiver A, the water descends through the tubes A and B, and ascends through the valve *e* and the other pipe or tube B into the penstock C. This part of the operation being performed and the valve *c* shut, that at *a* is suddenly opened, through which the steam rushes down the condensing pipe *c*, and in its passage meets with a jet of cold water from the injection cock *g*, by which it is condensed. A vacuum being made by this means in the receiver, the water is driven up to fill it a second time through the valves *ee*, by the pressure of the external air, when the steam-valve at *c* is again opened, and the operation repeated for any length of time the machine is required to work.

* Or the air blown out by steam; which may perhaps be less convenient than the method in the text.—N.

There are many advantages which a steam-engine on this construction possesses, beyond any thing of the kind hitherto invented; a few of which I shall beg leave to enumerate.

1. It is subject to little or no friction.

2. It may be erected at a small expence when compared with any other sort of steam-engine.

3. It has every advantage which may be attributed to Boulton and Watt's engines, by condensing out of the receiver, either in the penstock or at the level of the water.

4. Another very great advantage is, that the water in the upper part of the pipe* adjoining the receiver, acquires a heat by its being in frequent contact with the steam, very nearly equal to that of boiling water; hence the receiver is always kept uniformly hot as in the case of Boulton and Watt's engines.

5. A very small stream of water is sufficient to supply this engine, (even where there is no fall) for all the water raised by it is returned into the reservoir HHH.

From the foregoing reasons it manifestly appears that no kind of steam-engine is so well adapted to give rotatory motion to machinery of every kind as this. Its form is simple, and the materials of which it is composed are cheap; the power is more than equal to any other machine of the kind, because there is no deduction to be made for friction, except on account of turning the cocks, which is but trifling.

Its great utility is therefore evident in supplying water for every kind of work performed by a water-wheel, such as grist-mills, blast-furnaces, forges, &c.

* Not being thrown out by a side aperture, as in Plate XVII. Vol. I. of our Journal, but merely raised and depressed in the pipe AB—N. *(4 Nich. Jour. qto. 545.)*

Oliver Evans's Columbian Steam Engine.

Explanation.

A, the boiler—B, the working cylinder—C, the lever beam—D, the fly-wheel—E, the condenser—F, the water-pump—G, the supply pump—H, the furnace—I, the chimney flue—K, the safety-valve, which may be loaded with 100 or 150*lbs.* to the inch area; it will never need more, and it must never be fastened down.

Operation.

The boiler being filled with pure water as high as the dotted line, and the fire applied, the smoke enters the centre flue which passes through the centre of the water to ascend the flue I, and thus acts on a large surface.

When the steam lifts the safety-valve, it is then let into the cylinder by opening the throttle-valve, to drive the piston up and down, which, by rod 1, gives motion to the fly-wheel, and wheel 2 gives motion to a shaft, passing through the posts, to turn the spindle of the rotary-valves 3, 8, which lets the steam both off and on the cylinder at the proper time.

The steam escaping by pipe 4, curved and immersed in the water in box E, which is supplied by pump F, it is condensed, and the water formed, descends by pipe 5, into supply pump G, and is forced into the boiler again by pipe 6.

But boiling decomposes water slowly changing it into air incondensible. Therefore the shifting-valve 7, is necessary. This valve lifts at every puff of steam, and a small quantity of air escapes; and it shuts, and a vacuum is instantly formed, as the crank passes the dead points.

The small waste of water may be supplied by condensing part of the steam rising from the condensing water, to run down the pipe 9, through a hole in the key of a stop-

cock, $\frac{1}{32}$ parts of an inch diameter.—A small hole indeed to supply a boiler of twenty horses power.

No sediment can accumulate in the boiler, it being supplied by distilled water. Therefore it will last much longer, and require less fuel than others. Muddy, limestone, or salt water, or the juice of the sugar cane, &c. &c. may be used to condense; and as the engine works equally well while we boil away the condensing water, we may boil for salt, sugar, &c. in working the engine,—thus using the fuel for double purposes.

If the steam be confined by the load on the safety-valve, to raise its power to 100 pounds to the inch, area of the piston and the cylinder be nine inches in diameter, and the stroke of the piston three feet, the power will equal twenty horses hitched; and will grind 20 bushels of grain per hour, or saw 5000 feet of boards in 12 hours. If the steam be confined by 150 pounds, the power of the engine will be equal to 30 horses, when the steam is shut off at one third of the stroke, and striking 36 strokes per minute.—Double strokes double the power.

The more the steam is confined, and the shorter it be shut off by the regulator 8, the greater will be the power obtained by the fuel. For every addition of 30 degrees heat to the water doubles the power. So that doubling the heat of the water increases the power about 100 times. On these principles fuel may be lessened to one third part consumed by other engines., This engine is not more than one fourth the weight of others; is more simple, durable, and cheap, and more suitable for every purpose; especially for propelling boats and land carriages. It requires no more water than the fuel will evaporate in steam, and this steam may be employed to warm the apartments of factories; or the condenser E, could be used as a still to distill spirits; or a vat for paper making, boiler in a brewery, dye factory, &c. &c.

The patent right now belongs one half to the subscriber, Philadelphia; one fourth to George Evans, Pittsburgh; and one fourth to Luther Stephens, Lexington, Ky. Apply to either for engines, or for licences to use them.

OLIVER EVANS.

On the origin of Steam Boats and Steam Wagons.

BY OLIVER EVANS.

About the year 1772, being then an apprentice to a wheel-right, or wagon-maker, I laboured to discover some means of propelling land carriages, without animal power. All the modes that have since been tried (so far as I have heard of them) such as wind, treadles with ratched wheels, crank tooth, &c. to be wrought by men, presented themselves to my mind, but were considered as too futile to deserve an experiment; and I concluded that such motion was impossible for want of a suitable original power.

But one of my brothers, on a Christmas evening, informed me that he had that day been in company with a neighboring blacksmith's boys; who, for amusement, had stopped up the touch-hole of a gun barrel, then put in about a gill of water and rammed down a tight wad—after which they put the breech in the smith's fire; when it discharged itself with as loud a *crack* as if it had been loaded with powder.

It immediately occurred to me that here was the power to propel any wagon, if I could only apply it; and I sat myself to work to find out the means. I laboured for some time without success. At length a book fell into my hands describing the old atmospheric *steam engine.* I was astonished to observe that they had so far erred as to use the steam only to form a vacuum to apply the mere pressure of the atmosphere, instead of applying the elastic power of the steam for original motion; the power of which I supposed irresistible.

I renewed my studies with increased ardor, and soon declared that I could make *steam wagons*, and endeavored to communicate my ideas to others; but however practicable the thing appeared to me, my object only excited the ridicule of those to whom it was made known. But I persevered in my belief, and confirmed it by experiments that satisfied me of its reality.

In the year 1786, I petitioned the legislature of *Pennsylvania* for the exclusive right to use my improvements in flour mills, as also steam wagons, in that state. The committee to whom the petition was referred, heard me very patiently while I described the *mill* improvements, but my representations concerning *steam wagons* made them think me insane. They, however, reported favorably respecting my improvements in the manufacture of flour, and passed an act granting me the exclusive use of them as prayed for. This act is dated March——, 1787. But no notice is taken of the steam wagons.

A similar petition was also presented to the legislature of *Maryland*, Mr. *Jesse Hollingsworth*, from *Baltimore*, was one of the committee appointed to hear me, and report on the case. I candidly informed this committee of the fate of my application to the legislature of *Pennsylvania*, respecting the steam wagons—declaring, at the same time, without the encouragement prayed for, I would never attempt to make them; but that, if they would secure to me the right as requested, I would, as soon as I could, apply the principle to practice; and I explained to them the great elastic power of steam, as well as my mode of applying it to propel wagons. Mr. *Hollingsworth* very prudently observed, that the grant could injure no one, for he did not think that any man in the world had thought of such a thing before: he therefore wished the encouragement might be afforded, as there was a prospect that it would produce something useful.

This kind of argument had the desired effect, and a favorable report was made, May 21, 1787, granting to me, my heirs and assigns, for 14 years, the exclusive right to make and use my improvements in flour mills, and the steam wagons, in that state. From that period I have felt myself bound in honour to the state of *Maryland* to produce a steam wagon, as soon as I could conveniently do it.

In the year 1789, I paid a visit to *Benjamin Chandlee*, and sons, clockmakers, men celebrated for their ingenuity, with a view to induce them to join me in the expence and profits of the project. I shewed to them my draughts with the plan of the engine, and explained the expansive power of steam; all which they appeared to understand, but fearful of the expence and difficulties attending it, declined the concern. However they certified that I had shewn to them the drawings and explained the powers, &c.

In the same year, I went to *Ellicott's* mills on the *Petapsco*, near *Baltimore*, for the purpose of persuading Messrs. *Jonathan Ellicott* and brothers, and connections, (who were equally famous for their ingenuity,) to join me in the expence and profits of making and using steam wagons. I also shewed to them my drawings, and minutely explained to them the powers of steam. They appeared fully to comprehend all I said, and in return informed me of some experiments they themselves had made, one of which they shewed me. They placed a gun-barrel, having a hollow arm, with a small hole on one side at the end of the arm, similar to *Barker's* rotary tube mill, as described in the books; a gill of water put into this barrel, with fire applied to the breech, caused the steam to issue from the end of the arm with such force, as, by re-action, to cause the machine to revolve, as I judged, about one thousand times in a minute, for the

space of about five minutes, and with considerable force for so small a machine. I tarried here two days (May 10 and 11, 1789) using my best efforts to convince them of the possibility and practicability of propelling wagons, on good turnpike roads, by the great elastic power of steam. But they also feared the expence and difficulty of the execution, and declined the proposition. Yet they heartily esteemed my improvements in the manufacture of flour, and adopted them in their mills, as well as recommended them to others.

In the same year I communicated my project and explained my principles, to *Levi Hollingsworth*, Esq. now a merchant in Baltimore.* He appeared to understand them; but also declined a partnership in the scheme, for the same reasons as the former.

From the time of my discovering the principles and the means of applying them, I often endeavoured to communicate them to those I believed might be interested in their application to wagons or boats. But very few could understand my explanations, and I could find no one willing to risque the expence of the experiment.

In the year 1785 or 6, before I had petitioned the legislature, I fell in company with Mr. Samuel Jackson, of Redstone; and learning of him that he resided on the

* I certify that Oliver Evans did about the year 1789, communicate a project to me, of propelling land carriages by power of steam, and did solicit me to join him in the costs and profits of the same.

LEVI HOLLINGSWORTH.

Baltimore, November 16, 1812.

I do certify, that some time about the year 1781, 31 years ago, Oliver Evans, in conversation with me, declared, that by the power of steam he could drive any thing—wagons, mills, or vessels forward, by the same power, &c.

ENOCH ANDERSON.

November 15, 1812.

western waters, I endeavoured to impress upon his mind, the great utility and high importance of *steam boats*, to be propelled on them; telling him that I had discovered a steam engine so powerful according to its weight, that it would, by means of *paddle wheels* (which I described to him) readily drive a vessel against the current of those waters with so great speed as to be highly beneficial. Mr. Jackson proves that he understood me well, for he has lately written letters, declaring, that about twenty-six years before their date, I did describe to him the principles of the steam engine that I have since put into operation to drive mills, which he has seen—and that I also explained to him my plan for propelling boats by my steam engine, with *paddle wheels*, describing the very kind of wheels now used for this purpose; and that I then declared to him my intention to apply my engine to this particular object, as soon as my pecuniary circumstances would permit.

In the year 1800 or 1801, never having found a man willing to contribute to the expence, or even to encourage me to risque it myself, it occurred to me that though I was then in full health, I might be suddenly carried off by the yellow fever, that had so often visited our city, (Philadelphia) or by some other disease or casualty, to which all are liable, and that I had not yet discharged my debt of honour to the state of *Maryland*, by producing the steam wagon. I determined, therefore, to set to work the next day and construct one. I first waited upon *Robert Patterson*, esq. professor of mathematics in the university of Pennsylvania, and explained to him my principles, as I also did to Mr. *Charles Taylor*, steam engineer, from England. They both declared these principles to be new to them, and highly worthy of a fair experiment, advising me without delay to prove them; in hopes I might produce a more simple, cheap and pow-

erful steam engine than any in use. These gentlemen were the only persons who had such confidence, or afforded me such advice. I also communicated my plans to *B. H. Latrobe*, esq. at the same time; who publicly pronounced them chimerical, and attempted to demonstrate the absurdity of my principles, in his report to the *Philosophical society of Pennsylvania*, on steam engines; in which same report he also attempts to shew the impossibility of making steam boats useful, on account of the weight of the engine; and I was one of the persons alluded to, as being seized with the *steam mania*, conceiving that wagons and boats could be propelled by steam engines. The liberality of the members of the society caused them to reject that part of his report which he designed as demonstrative of the absurdity of my principles; saying they had no right to set up their opinion as a stumbling block in the road of any exertions to make a discovery. They said, I might produce something useful, and ordered it to be stricken out. What a pity they did not also reject his demonstrations respecting steam boats! for notwithstanding them, they have run, are now running, and will run: so has my engine and all its principles, completely succeeded—and so will land carriages, as soon as these principles are applied to them, as explained to the legislature of *Maryland*, in 1787, and to others long before.

In consequence of the determination above alluded to, I hired hands and went to work to make a steam wagon, and had made considerable progress in the undertaking, when the thought struck me that as my steam engine was entirely different in form as well as in its principles from all others in use, that I could get a patent for it, and apply it to mills more profitably than to wagons; for until now I apprehended that as steam mills had been used in England, I could only obtain a patent for wagons and

boats. I stopped the work immediately, and discharged my hands, until I could arrange my engine for mills, laying aside the steam wagon for a time of more leisure.

Two weeks afterwards, I commenced the construction of a small engine for a mill to grind plaister of Paris—the cylinder six inches in diameter, and stroke of the piston eighteen inches—believing that with $ 1000, I could fully try the experiment. But before I was done with experiments, I found that I had expended $ 3,700—all that I could command. I had now to begin the world anew at the age of forty-eight, with a large family to support. I had calculated that if I failed in my experiment, the credit I had would be entirely lost; and without money or credit, at my advanced age, with many heavy incumbrances, my way through life appeared dark and gloomy indeed. But I succeeded perfectly with my little engine, and preserved my credit. I could break and grind 300 bushels of plaister of Paris, or 12 tons, in 24 hours; and to shew its operations more fully to the public, I applied it to saw stone on the side of Market-street, where the driving of twelve saws, in heavy frames, sawing at the rate of 100 feet of marble stone in 12 hours, made a great shew, and excited much attention. I thought this was sufficient to convince the thousands of spectators of the utility of my discovery: but I frequently heard them enquire if the power could be applied to saw timber as well as stone, to grind grain, propel boats, &c. and though I answered in the affirmative, I found they still doubted. I therefore determined to apply my engine to all new uses, to introduce it and them to the public.

This experiment completely tested the correctness of my principles, according to my most sanguine hopes. The power of my engine rises in a geometrical proportion, while the consumption of fuel has only an arithmetical ratio; in such proportion that every time I added

one-fourth more to the consumption of fuel, the powers of the engine were doubled; and that twice the quantity of fuel required to drive one saw would drive 16 saws, at least; for when I drove two saws the consumption was 8 bushels (coal) in 12 hours, but when 12 saws were driven, the consumption was not more than 10 bushels; so that the more we resist the steam the greater is the effect of the engine. On these principles, very light, but powerful engines, can be made, suitable for propelling boats and land carriages, without the great incumbrance of their own weight, as mentioned in Mr. *Latrobe's* demonstrations.

In the year 1804, I constructed at my works, situate a mile and a half from the water, by order of the board of health of the city of Philadelphia, a machine for cleansing docks. It consisted of a large flatt, or scow, with a steam engine of the power of five horses on board, to work machinery to raise the mud into flatts. This was a fine opportunity to shew the public that my engine could propel both land and water carriages, and I resolved to do it. When the work was finished, I put wheels under it; and though it was equal in weight to *two hundred barrels of flour*, and the wheels fixed with wooden axletrees, for this temporary purpose, in a very rough manner, and with great friction, of course, yet with this small engine I transported my great burthen to the *Schuylkill* with ease; and when it was launched in the water, I fixed a paddle wheel at the stern, and drove it down the *Schuylkill*, to the *Delaware*, and up the *Delaware* to the city, leaving all the vessels going up behind me, at least, half way; the wind being a-head.

Some wise men undertook to ridicule my experiment of propelling this great weight on land, because the motion was too slow to be useful. I silenced them by answering, that I would make a carriage, to be propelled

by steam, for a bet of \$ 3000, to run upon a level road against the swiftest horse they would produce. I was then as confident, as I am now, that such velocity could be given to carriages.

Having no doubt of the great utility of steam carriages on good turnpike roads, with proper arrangements for supplying them with water and fuel, and believing that all turnpike companies were deeply interested in putting them into operation, because they would smooth and mend the roads, instead of injuring them as the narrow wheels do, on the 26th of September, 1804, I submitted to the consideration of the Lancaster turnpike company, a statement of the costs and profits of a steam carriage to carry 100 barrels of flour, 50 miles in 24 hours—tending to shew, that one such steam carriage would make more nett profits than 10 wagons drawn by five horses each, on a good turnpike road, and offering to build such a carriage at a very low price. My address closed as follows:

"It is too much for an individual to put in operation, every improvement which he may invent.

"I have no doubt but that my engines will propel boats against the current of the Mississippi, and wagons on turnpike roads, with great profit. I now call upon those whose interest it is, to carry this invention into effect. All which is respectfully submitted for your consideration."

In the year 1805, I published a book describing the principles of my steam engine, with directions for working it, when applied to propel boats against the current of the *Mississippi*, and carriages on turnpike roads. And I am still willing to make a steam carriage that will run 15 miles an hour, on good level rail-ways, on condition that I have double price if it shall run with that velocity, and nothing for it, if it shall not come up to that velocity. What

can an inventor do more than to insure the performance of his inventions? Or, I will make the engine and apparatus, at a fair price, and *warrant* its utility for the purpose of conveying heavy burthens on good turnpike roads.

I feel it just to declare that, with Mr. *Latrobe*, I myself did believe, that with the ponderous and feeble steam engine, now used in boats, they could never be made useful in competition with sail boats, or to ascend the *Mississippi*, esteeming the current more powerful than it is. But I rejoice that, with him I have been mistaken; for I have lived to see boats succeed well with those engines; and I still hope to see them so completely excelled and out-run by using my engines, as to induce the proprietors to exchange the old for the new, more cheap and more powerful principles.

I have been highly delighted in reading a correspondence between *John Stevens*, Esq. and the commissioners appointed by the legislature of *New York*, for fixing on the scite of the great canal proposed to be cut in that state. Mr. *Stevens* has taken a most comprehensive and very ingenious view of this important subject, and his plan of rail-ways for the carriages to run upon, removes all the difficulties that remained. I have had the pleasure, also, of hearing gentlemen of the keenest penetration, and of great mechanical and philosophical talents, freely give into the belief, that steam carriages will become very useful. Mr. *John Ellicott*, (of John) proposed to make roads of substances, such as the best turnpikes are made with, with a path for each wheel to run on, having a rail-way on posts in the middle to guide the tongue of the wagon, and to prevent any other carriage from travelling on it. Then, if the wheels were made broad and the paths smooth, there would be very little wear. Such roads might be cheaply made; they would last a long time, and

require very little repair. Such roads, I am inclined to believe, ought to be preferred, in the first instance, to those proposed by Mr. *Stevens;* as two ways could be made, in some parts of the country, for the same expence as one could be with wood. But either of the modes would answer the purpose, and the carriages might travel by night as well as in the day.

When we reflect upon the obstinate opposition that has been made by a great majority to every step towards improvement; from bad roads to turnpikes, from turnpikes to canals, from canals to rail-ways for horse carriages, it is too much to expect the monstrous leap from bad roads to rail-ways for steam carriages, at once. One step in a generation is all that we can hope for. If the present shall adopt canals, the next may try the rail-ways with horses, and the third generation use the steam carriages.

But why may not the present generation, who have already good turnpikes, make the experiment of using steam carriages upon them? They will assuredly effect the movement of heavy burthens, with a slow motion, of two and a half miles an hour; and as their progrees need not be interrupted, they may travel fifty or sixty miles in the 24 hours.—This is all that I hope to see in my time, and though I never expect to be concerned in any business requiring the regular transportation of heavy burthens, [on land] because if I am connected in the affairs of a mill it shall be driven by steam, and placed on some navigable water, to save land carriage—yet I certainly intend as soon as I can make it convenient, to build a steam carriage that will run on good turnpike roads, on my own account, if no other person will engage in it; and I do verily believe that the time will come when carriages propelled by steam will be in *general use*, as well for the transportation of passengers as goods, travelling at the rate of fifteen miles an hour, or 300 miles per day.

It appears necessary to give the reader some idea of the principles of the steam engine which is to produce such novel and strange effects; and this I will endeavour to do in as few words as I can, by shewing the extent to which the principles are applied already.

To make a steam as irresistible, or powerful as gunpowder, we have only to confine and increase the heat by fuel to the boiler. A steam engine with a working cylinder only nine inches in diameter, and a stroke of the piston three feet, will exert a power sufficient to lift from 3,000 to 10,000 pounds perpendicularly, two and a half miles per hour. This power applied to propel a carriage on level roads or rail-ways, would drive a very great weight with much velocity, before the friction of the axletree or resistance of the atmosphere would balance it.

This is not speculative theory. The principles are now in practice, driving a saw-mill at *Manchacks* on the Mississippi; two at *Natchez*, one of which is capable of sawing 5000 feet of boards in 12 hours; a mill at *Pittsburgh*, able to grind 20 bushels of grain per hour; one at *Marietta* of equal powers; one at *Lexington*, (Ky.) of the same powers; one a paper-mill, of the same; one of one fourth the power at *Pittsburgh:* one at the same place of 3½ times the power, for the forge, and for rolling and splitting sheet iron; one of the power of 24 horses at *Middletown*, (Con.) driving the machinery of a cloth manufactory; two at *Philadelphia* of the power of five or six horses, and many making for different purposes; the principles applying to all purposes where power is wanted.

OLIVER EVANS.

Ellicott's Mills on the Patapsco,
Nov. 13, 1812.

A new fire engine.—Make a small engine of tin and leather, to contain one cubit foot, or 6 gallons of water, which weighs 62½ lbs. with a piston to project the water

through a pipe to be guided by the hand. This may be carried by a man on his breast, hung by straps round his neck and must have two stirrups pending from the lower end of the piston rod.

Fifty men thus equipped, who would on an alarm, proceed immediately to the fire, and on their way fill their engines and ascend to the roof, or upper loft, or as the case may be, to come near the fire; then by stooping and putting their feet in the stirrups, and straightening themselves, they might exert such force as to eject the water thirty feet, horizontally, or fifteen feet perpendicularly, to strike the burning materials. Three hundred gallons of water, early applied and so immediately powerful to the spot wanting it, would extinguish most fires before the great engines could get into play. But the great engines must be preserved, and used on other occasions. O. E.

Extract from the (Philadelphia) Democratic Press of January 28, 1813.

"An experiment was lately made in Charles River, near Boston, to shew the velocity of a steam boat, constructed for the conveyance of passengers, &c. in the Middlesex canal. The boat was driven seven miles and six furlongs in sixty minutes; and there is no doubt by the best informed that it will go nine miles."

The steam engine in the said boat was constructed by Oliver Evans, on his improved principles adapted to the purpose of propelling boats and land carriages; and which he is convinced, will propel boats ten miles and upwards per hour, through still water.

The improvements made by Mr. Watt, may be summed up thus,

1st. Condensing the steam in a vessel separate and at a distance from the cylinder, which is now no longer

cooled by the injection water, as in Newcomen's or the atmospheric engine.

2dly. Making an approach to a vacuum by pumping out the air, which always, to a certain degree, accompanies the steam, and by its elasticity re-acts against the under side of the piston.

3dly. Keeping the outside of the cylinder in which the piston works, hot, by the intervention of steam between it and a casing.

4thly. The parallel motion of the beam, by which the stiff upwright rod attached to the beam and the piston presents its perpendicularity during the stroke.

5thly. Depressing the piston by steam instead of the atmosphere.

6thly. Keeping the top of the piston hot by the casing between the piston and the outward air, so that the steam let on above, is of the same temperature always as that below.

7thly. Consuming the smoke of the fuel, by making it pass through and over the red-hot coals.

8thly. Supplying the boiler with the hot injection water.

9thly. The application of the steam pipe above the water in the boiler, to ascertain when the water is too high: and the mode of opening the valve of the feeder, when the water sinks too low in the boiler; by the floating stone instead of the ball-cock.

10thly. The circular motion communicated to the fly wheel by means of the sun and planet wheels.

Mr. Cartwright's improvements consist in

1st. The method of giving the necessary perpendicular motion to the piston rod.

2dly. The condensing the steam by expanding it in a thin surface between metal balls cooled with water inside and outside, so that a great surface of steam is exposed

to the action of cold, in the manner as a great surface of air is admitted to the wick of Argand's lamp.

3dly. The accurate fitting of the metal piston to the cylinder by means of springs, which saves much trouble and expence in packing.

4thly. As all the steam is brought back into the boiler, it enables us to use ardent spirits, if necessary.

An account and drawing of Cartwright's engine may be seen in 1 Tilloch's Phil. Mag. 1.

I do not find, however, that Cartwright's engines are much in use.

Mr. Hornblower's improvements do not seem to consist in the adaption of any new principle, for reasons stated by professor Robison, in the article steam engine, in the Edinburgh Encyclopedia, p. 771, but in the methods used to make his collars air tight, in the structure of his condensing vessel, and the framing of his beam. A plate of Hornblower's engine is given by professor Robison in that article, and by Dr. Gregory in the 2nd vol. of his mechanics.

The improvements introduced by Mr. Woolf consist in

1st. His ascertaining the law of the expansion of steam, by a volume for each pound per square inch on the safety-valve: hence

2dly. In his using steam at much higher temperature than in the common engine: and

3dly. In his using it twice over in separate cylinders; though this idea seems to have occurred also to Mr. Hornblower.

4thly. In applying heat to the hot steam in the second cylinder: and using as the metalline substances as the mean of communicating and preserving heat to the steam.

5thly. In the form of his boilers, of which I shall give

a drawing in my next number, as I apprehend it is a great improvement on the common form.

But there is some similarity to Mr. Woolf's ideas in the patents of Mr. Sadler and Mr. Trevethick, as will appear from the description of his engine in the second volume of Nicholson's Journal, quto. series, p. 231.

Mr. Sadler's improvements consist in

1st. His working without a lever or beam.

2dly. Part of the steam previous to condensation, is employed a second time in another cylinder, the piston of which is depressed by the atmosphere. By this second application, it performs the office of an air pump, and adds to the total force of the machine.

Mr. Trevethick's engine worked by the force of a column of water inclosed in a pipe, may be understood from the description of it in 1 Nicholson's Journal, 8vo. p. 161. But his steam engine appears to be worked by steam of very high temperature, which is not condensed but permitted to escape.

The article "Steam Engine," to be concluded in the next.

INSRUCTIONS FOR PARENTS.

By Ch. Gotth. Salzmann.

'1. How to make yourself hated by your children.—Treat them with injustice, their hatred will naturally follow. Or this purpose may be effected by one parent's setting the children against the other.' Mr. S. here instances the very common practice of mothers threatening children with being punished by their father, or condoling with them when their father has corrected them. 'Be insensible to the caresses of your children, or take no share

in their pleasures, and they will soon feel an aversion to you. Deny your children innocent gratifications. Treat the little mistakes of your children with ridicule. 2. How to make your children distrust you.—Tell them untruths, and break your word with them. 3. How to make your children despise you.—Acquaint them with your faults. Lay many injunctions on them, without seeing whether they be obeyed; threaten them often, without executing your threats; and they will soon laugh at you. 4. How to make your children soon hate and envy each other.—Bestow all your affection on one, and none on the rest. Praise one child when you punish another. Take no notice of the injuries your children do one another, and never examine into the occasions of their quarrels. 5. How to stifle in your children the sentiments of humanity.—Speak evil of people frequently in their presence. 6. How to teach children cruelty.—Instruct them early to take pleasure in the pains and sufferings of animals. 7. How to make your children revengeful.—When they are angry, give them something to vent their anger upon. When your child is hurt by any one, represent the mischief as very great, and never attribute any blame to him. 8. How to teach children envy.—Represent the happiness of other people as a misfortune to them. 9. How to make children malicious.—When once you have brought them to regret the happiness of others, they will soon take pleasure in their misfortunes. 10. How to make children afraid of certain animals.—Endeavour to persuade them, that they are venomous. 11. How to give children an aversion to people of different religious opinions from themselves.—Tell them, that God hates all who do not believe what they do. Set them a good example of this in your own practice. 12. How to make children insensible to the beauties of nature.—Reprove them when they notice any productions of nature, and call

off their attention by promising them other gratifications. 13. How to teach children to see spirits.—Tell them many stories of ghosts and apparitions. 14. How to make children afraid of thunder.—Always appear greatly alarmed as soon as you perceive a thunder cloud. 15. How to make children afraid of dying.—Represent death to them as the greatest of all evils. 16. How to teach children to hate religion.—Depict God to them as a being to be dreaded. Bring them to an acquaintance with religion, by means not pleasant to them. Inspire them with hatred and contempt for the teachers of religion. 17. How to render children capricious. Do every thing they desire. 18. How to instruct children to tell lies.—Excite them early to say what is not true. Laugh at, and reward their lies. Believe every thing they say. Punish them, when they confess the truth. Let your questions give them occasion to tell lies. 19. How to accustom your children early to slander.—Encourage them to speak evil of others. 20. How to make children unhappy and discontented in their stations.—Teach them to view every thing on its worst side. Speak to them highly of things they cannot obtain. 21. How to render children obstinate.—Pay no heed to their modest requests; but consent to whatever they demand with persevering importunity. 22. How to make children useless members of society, and joyless in themselves.—Force them to some employment for which they have neither capacity nor inclination. 23. How to render children lascivious.—Take care, that they always sleep two together. Let them lie very warm, do not suffer them to rise too early. In the choice of a tutor, consider his accomplishments more than his virtue and morals. Caress your wife before them. 24. How to make children voluptuous.—Indulge their appetites in every thing. Let them have plenty of money, without inquiring what

they do with it. Give them dainties, and in giving commend them highly. 25. How to make children gluttons.—Take care that their bellies are always well stuffed. 26. How to render your children weary of being good. —Notice not their endeavours to be good, and they will soon be weary of them. 27. How to make children stupid.—Give them a good box on the ear, every time they forget any thing. Give yourself up to drunkenness, and you will necessarily have stupid children. Make your children prematurely wise, and they will soon become stupid. 28. How to make your children unhandy.—See that they have every thing done for them. 29. How to teach children negligence.—Check early their love of order. 30. How to make children vain.—Instruct them soon in the great value of dress. Introduce them into company as early as possible. 31. How to give children an inclination for idleness.—Represent to them frequently the grievousness of work, and the pleasure of being idle. 32. How to make children covetous.—Instil into them, as soon as possible, high notions of the value of money. 33. How to render children deaf to good advice.—Be incessantly preaching to them their duties. 34. A couple of infalliable means of leading children into all kinds of vice. —Frequently practice before them those vices you wish them to adopt. Leave your children to themselves and the servants. 35. Universal means of depriving children of health and life.—Make them tender by keeping them extremely warm. Deprive them of fresh air. Accustom them to delicate and dainty food. Give them plenty of medicines. Let them have infirm and unhealthy nurses. 36. An excellent method to make children cripples.—Let them wear stays.'

POLITICAL ECONOMY.

Having observed in the second number of the Emporium of Arts, an invitation for communications upon the subject of political economy, I am induced to send you the result of some attention and enquiry. It is with diffidence opinions are presented differing from your own; with hopes however that the public may be benefited by your further elucidations. The object of this writer will be gained if these remarks should be the means of engaging abler pens: and it is worthy of exertion to approximate the truth, in a science so difficult to develope, that it may be considered in its infancy, its first principles being yet unsettled.

All wealth is derived from the natural productions of the earth, and labour: but as it is labour alone that accumulates a surplus, and even attracts and concentrates produce, without any original possession, labour is entitled to the first place, and industry may be considered the parent of wealth.

A large surplus produce, whether derived from domestic labour, or from capital employing foreign labour, gives a nation prosperity; accumulated and condensed it becomes wealth, which is disseminated through the country by a large consumption; and united, as it must be, with numerous, active and intelligent population, constitutes power.

Of the different opinions which have prevailed, as to the most profitable mode of employing national industry, the principal are embraced in the agricultural and commercial systems.

The agricultural system supposes the greatest advantage to be derived from the multiplication of the productions natural to any country; particularly such as contribute directly to human subsistence.

The commercial system supposes a benefit is derived from a balance of trade; or an excess of exports over imports.

Agriculture is necessary to subsistence; the employment of the surplus produce is matter of choice: and whenever more that is useful can be obtained by means of exchange, than can be produced at home, by the same labour and capital which is employed in effecting the exchange; then a portion of the inhabitants may be more profitably engaged in foreign commerce than in domestic employments. And this must always be the case so long as a considerable diversity of circumstances exists among nations. A country possessing favourable soil and climate, valuable productions, and numerous population, with arts highly improved, may dispense with foreign commerce; may enjoy more prosperity without it, than other nations may be able to attain with its assistance: but as no nation can possess every advantage, in as great degree as all other nations, a judicious exchange of commodities will always be productive of profit; enriching those individuals whose capitals and services are employed, and rendering them instrumental in diffusing general prosperity.

It is stated that foreign commerce, by a diversion of capital and labour, withholds the means of domestic improvement. In extensive countries certain portions will possess facilities for foreign commerce superior to other portions; and as commercial adventurers seek only the best markets, it may often happen that the commercial districts purchase supplies abroad, which might be furnished, perhaps on terms nearly as favourable, by some other district at home, which thus loses the benefit of the supply. But a limitation of supply to home production would be to establish a system of monopoly, which must always be considered inequitable, except when granted as

a reward for public services, or resorted to as a measure of necessity for the public welfare. That such supplies cannot be obtained upon terms equally favourable at home, is proved by their being sought abroad; as no one encounters the hazard of foreign commerce, but for the sake of the profit which attends it. If commercial districts should be obliged to purchase such supplies at home, it must be at an advanced price. The direct public benefit would be the same, with a different division of the profit. The commercial districts would lose, and the supplying districts would gain. And it may well be questioned, whether domestic industry is entitled to greater advantage over foreign competition, at the expence of mercantile labour and capital, and against the domestic consumer, than at all times exists by means of the duties upon imports, which it is the concern of a wise government judiciously to regulate. Were it the case that supplies derived from foreigners, might be furnished by labor and capital otherwise unemployed, a monopoly might well be contended for; but the greatest effect that can be produced, among an enlightened and industrious people, is a change of employment, by the prosecution of business more or less profitable.*

There is, perhaps, no difficulty in discovering the advantages of commerce to individuals, and even to particular districts: it is in estimating its *national* bearings, that obscurity is found to exist. Arguments drawn from a balance of trade, even if official values could be fully relied upon, appear to be altogether fallacious; the amount of freight and expences being unknown.

* The duty on imports may furnish, in some measure, an indemnification to supplying and manufacturing districts, for any disadvantage they may suffer, from a preference granted to the shipping of maritime districts over foreign vessels.

May not the national advantage of foreign commerce be traced in the following manner?

Some nations possess an abundance of rude produce; others, flourishing manufactures; the interchange of these by commerce, appropriates to the commercial nation the peculiar advantages of every other; and *raises the whole value of its labour*, by sale of manufactured articles, to nations abounding in rude produce, and where skilful labour is dear—or of rude produce to nations possessing improved manufactures and numerous population, and where rude produce is consequently dear. This interchange of labour between nations, is similar in its effects to the division of labour among individuals, to which the most powerful effects have been justly attributed; or it may be considered as a division of labour upon a large scale; giving the highest stimulus to industry, both by introducing new articles of convenience, and extending the markets for home products; and realizing, without loss to the nation, a profit to the capital employed in foreign commerce, upon the whole of the foreign labour engaged in furnishing the articles of trade; which operates like an accession of population and territory.*

* These hints might be extended, shewing the increase of value of the whole national stock; the direction given to labour and production, spreading wealth over the country, and adopting the advantages of other nations as fast as they can be realized at home; it is through the channel of capital, wealth must flow; land is limited by nature, and labour must be fed, but capital may always make terms and embrace opportunities,—by which labour is gradually reduced to the standard of subsistence. The basis of capital is labour, whether employed in refined manufactures, or in bringing forward natural productions, according to circumstances of situation, soil, climate, abundance or cheapness of land, &c. Where great diversity exists among foreign nations, between whom trade is free, commercial capital flows into what is called carrying trade, which is perhaps only effecting two exchanges at one operation. It is, however, only proposed to call attention, and leave the subject for the readers reflection.

It appears reasonable in this view, that foreign commerce should give greater profit than domestic pursuits; and that commerce is the most profitable occupation, might be inferred from the avidity with which it has always been followed where circumstances favoured it, as well as by the great wealth accumulated by commercial nations.

Foreign commerce, thus advantageous to individuals and the nation, is also beneficial to the world; its direct tendency being to ameliorate human condition. It also adds to the splendor and strengthens the arm of government, by the concentration of wealth in a tangible form, passing frequently under the eyes and hands of its officers, furnishing the means of extensive indirect taxation; a species of contribution of all others the most freely paid, as it is in a great measure concealed from the labourer and consumer, and furnishes a benefit to the capitalist who advances or collects it. A consideration of this circumstance may anticipate an objection which might be made, that the direct wages of labour, are not always high in commercial countries.

It is, perhaps, to be numbered among the disadvantages of commerce, that the power conferred by it, is attended frequently, perhaps inevitably, with abuse. Wars between distant nations can scarcely arise but by means of commerce. It occasions the loss of many lives, both by the dangers of the ocean, and exposure in unhealthy climates. If it acquires wealth rapidly, it also introduces luxury and vice.

Such appear to be the advantages and disadvantages of commerce. It is more productive of wealth than any other employment: and, like most benefits, it is acquired with considerable dangers and sacrifices. Its inherent energy is so powerful, that it can seldom require encouragement: although, in the present state of the world, it

may want protection, and the adoption of measures to prevent inconvenient interference of foreigners; while the watchful care of government may be needful, to see that labour and capital are not entirely diverted from those objects of necessary supply and public security, which the welfare of the community may imperiously demand.

As the subject of public finances forms an important branch of political economy, these observations will be finished with remarking, that the employment of public credit, for useful purposes, in a young and growing country, if within the bounds of its capacity to repay, may be judicious; like the loans to young industrious traders; while the accumulation of debt by a nation, for unprofitable purposes, can only be attended with the wider mischief, the further and longer it is extended; for no modifications or changes of debt, by means of any combination or institution, will furnish any real or permanent relief, except provision is made by a surplus revenue; although by taking up floating paper, a sinking fund, so called, may enhance the market value of stock, and thus extend the power of government. M.

Massachusetts.

I make no remark on the above, because I do not want now to prolong this discussion. Having inserted Dr. Bollman's essay, and the above paper, it must suffice for the present. Hereafter perhaps I may insert my abridgment of *Ganilh*, with notes, and then close the subject. T. C.

STATISTICS.

I have collected some tables that relate to the statistical facts of Great Britain, France, and the United States: some more, some less common; all of them important to persons who know what use to make of tables of this kind. They are not complete, nor do I know how to make them so; but incomplete as they are, I have had great trouble in collecting them; and thus collected they will be more useful in the neighbourhood of each other, than scattered among many publications of partial circulation. Facts of this kind, furnish the only grounds of legitimate argument on questions of statistics and political economy. Hereafter, either I or some other person will be induced to add gradually to this collection, other recent statements as opportunities arise, and thus supply the foundations for reasoning on the causes that influence variations in the facts at different periods.

The facts that influence, or that demonstrate the national prosperity or otherwise of the European powers, are greatly interesting to ourselves. We can only reason from what we know; and we may be the wiser if we please, for the experience of others, as well as our own.

Great Britain and France, are now pursuing very different policies, and all the facts that give us an insight into the sources of their success or their failure, cannot but be of great moment to those, who will take the pains of comparing and reflecting. T. C.

The Epochs.		*The Ships cleared Outwards.* Tons English.	Tons Foreign.	Total.
The Restoration	1663 1669	95,266	47,634	142,900
The Revolution	1688	190,533	95,267	285,800
The Peace of Ryswick	1697	144,264	100,524	244,788
The last years of William III.	1700 1 2	273,693	43,635	317,328
The Wars of Anne	1709	243,693	45,625	289,318
	1712	326,620	29,115	355,735
The first of George I.	1713 14 15	421,431	26,573	448,004
The first of George II.	1726 27 28	432,832	23,651	456,483
The peaceful years	1736 37 38	476,941	26,627	503,568
The War of	1739 40 41	384,191	87,260	471,451
The peaceful years	1749 50 51	609,798	51,386	661,184
The War of	1755 56 57	451,254	73,456	524,710
The first of Geo. III. WAR:	1760	471,241	102,737	573,978
	61	508,220	117,835	626,055
	62	480,444	120,126	600,570
PEACE:	1763	561,724	87,293	649,017
	64	583,934	74,800	658,734
	65	651,402	67,855	719,257
	66	684,281	61,753	746,034
	67	645,835	63,206	709,041
	68	668,786	72,734	741,520
	69	709,855	63,020	772,875
	70	703,495	57,476	760,971
	71	773,390	63,532	836,922
	72	818,108	72,603	890,711
	73	771,483	54,820	826,303
	74	798,240	65,273	863,513

The Epochs.		The Ships cleared outwards. Tons English.	Tons Foreign.	Total.
WAR:	1775	783,226	64,860	848,086
	76	778,878	72,188	851,066
	77	736,234	83,468	819,702
	78	657,238	98,113	755,351
	79	590,911	139,124	730,035
	80	619,462	134,515	753,977
	81	547,953	163,410	711,363
	82	552,851	208,511	761,362
	83	795,669	157,969	953,638
PEACE:	1784	846,355	113,064	959,419
	85	951,855	103,398	1,055,253
	86	982,132	116,771	1,098,903
	87	1,104,711	132,243	1,236,954
	88	1,243,206	121,932	1,365,138
	89	1,343,800	99,858	1,443,658
	90	1,260,828	144,132	1,404,960
	91	1,333,106	178,051	1,511,157
	92	1,396,003	169,151	1,565,154
WAR:	1793	1,101,326	180,121	1,281,447
	94	1,247,398	209,679	1,457,077
	95	1,030,058	370,238	1,400,296
	96	1,108,258	454,847	1,563,105
	97	971,596	379,775	1,351,371
	98	1,163,534	345,132	1,508,666
	99	1,145,314	390,612	1,535,926
	1800	1,269,329	654,713	1,924,042
	1	1,190,557	767,816	1,958,373
PEACE:	1802	1,459,689	435,427	1,895,116
WAR:	1803	1,245,560	543,208	1,788,768
	4	1,248,796	553,267	1,802,063
	5	1,284,691	572,961	1,857,652
	6	1,258,903	538,700	1,897,603
	7	1,190,232	600,840	1,791,072
	8	1,153,488	272,104	1,425,592
	9	1,318,508	674,680	1,993,188

The Epochs.		*The Value of Cargoes exported.*		
		English.	Scots.	Total.
The Restoration	1663, 1669	£.2,043,043	......	£.2,043,043
The Revolution	1688	4,086,087	......	4,086,087
The Peace of Ryswick	1697	3,525,907	......	3,525,907
The last years of William III.	1700, 1, 2	6,045,432	......	6,045,432
The Wars of Anne	1709	5,913,357	......	5,913,357
	1712	6,868,840	......	6,868,840
The first of George I.	1713, 14, 15	7,696,573	......	7,696,573
The first of George II.	1726, 27, 28	7,891,739	......	7,891,739
The peaceful years	1736, 37, 38	9,993,232	......	9,993,232
The War of	1739, 40, 41	8,870,499	......	8,870,499
The peaceful years	1749, 50, 51	12,599,112	......	12,599,112
The War of	1755, 56, 57	11,708,515	663,401	12,371,916
The first of Geo. III. WAR:	1760	14,694,970	1,086,205	15,781,175
	61	14,873,191	1,165,722	16,038,913
	62	13,545,171	998,165	14,543,336
PEACE:	1763	14,487,507	1,091,436	15,578,943
	64	16,512,404	1,243,927	17,756,331
	65	14,550,507	1,180,867	15,731,374
	66	14,024,964	1,163,704	15,188,668
	67	13,844,511	1,245,490	15,090,001
	68	15,117,983	1,502,150	16,620,133
	69	13,438,236	1,563,053	15,001,289
	70	14,266,654	1,729,915	15,996,569
	71	17,161,147	1,857,334	19,018,481
	72	16,159,413	1,560,756	17,720,169
	73	14,763,253	1,612,175	16,375,428
	74	15,916,344	1,372,143	17,288,487

The Epochs.		*The Value of Cargoes Exported.*		
		English.	Scots.	Total.
WAR:	1775	£15,202,366	1,123,998	£16,326,364
	76	13,729,726	1,025,973	14,755,699
	77	12,653,363	837,643	13,491,006
	78	11,551,070	702,820	12,253,890
	79	12,693,430	837,273	13,530,703
	80	11,622,333	1,002,039	12,624,372
	81	10,569,187	763,109	11,332,296
	82	12,355,750	653,709	13,009,459
	83	13,851,671	829,824	14,681,495
PEACE:	1784	14,171,375	929,900	15,101,275
	85	15,762,593	1,007,635	16,770,228
	86	15,385,987	914,738	16,300,725
	87	17,181,032	1,115,134	18,296,166
	88	16,934,994	1,189,088	18,124,082
	89	18,843,221	1,170,076	20,013,297
	90	18,884,716	1,235,404	20,120,120
	91	21,435,459	1,296,535	22,731,994
	92	23,674,316	1,230,884	24,905,200
WAR:	1793	19,365,428	1,024,751	20,390,180
	94	25,663,272	1,084,811	26,748,083
	95	26,146,346	976,991	27,123,338
	96	39,196,190	1,322,723	30,518,913
	97	27,699,889	1,217,121	28,917,010
	98	31,922,580	1,669,197	33,591,777
	99	34,074,698	1,916,630	35,991,329
	1800	40,805,947	2,346,069	43,152,019
	1	39,256,330	2,844,502	42,100,832
PEACE:	1802	43,518,104	2,602,858	46,120,962
WAR:	1803	29,385,273	2,053,222	31,438,495
	4	32,199,058	2,252,319	34,451,377
	5	32,404,978	2,504,867	35,909,845
	6	33,810,570	2,716,614	36,527,184
	7	31,829,733	2,736,838	34,566,571
	8	31,737,925	2,816,342	34,554,267
	9	45,918,663	4,383,100	50,301,763

The Epochs.			*The Balance of Trade.*		
			English.	Scots.	Total.
The Restoration		1663 1669	Unfavor- able.	......	......
The Revolution		1688	Doubtful.	......	......
The Peace of Ryswick		1697	£ 43,320	......	£ 43,320
The last years of William III.		1700 1 2	1,386,832	......	1,386,832
The Wars of Anne		1709	2,116,451	......	2,116,451
		1712	3,014,175	......	3,014,175
The first of George I.		1713 14 15	1,904,151	......	1,904,151
The first of George II.		1726 27 28	3,514,768	......	3,514,768
The peaceful years		1736 37 38	4,642,502	......	4,642,502
The War of		1739 40 41	2,455,313	......	2,455,313
The peaceful years		1749 50 51	6,521,964	......	6,521,964
The War of		1755 56 57	4,046,465	......	4,046,463
The first of Geo. III.	WAR:	1760	5,746,270	235,412	5,981,682
		61	6,822,051	417,082	7,239,133
		62	5,263,858	289,240	5,553,098
	PEACE:	1763	4,495,146	187,545	4,682,691
		64	6,148,096	357,575	6,505,671
		65	3,660,764	258,466	3,919,230
		66	2,549,189	182,715	2,731,904
		67	1,770,555	222,293	1,992,848
		68	3,239,322	265,501	3,504,823
		69	1,529,676	337,523	1,867,199
		70	2,049,716	514,556	2,564,272
		71	4,339,151	471,005	4,810,156
		72	2,860,961	350,492	3,211,453
		73	3,356,412	496,376	3,852,788
		74	2,888,678	169,866	3,058,544

The Epochs.		The Balance of Trade. English.	Scots.	Total.
WAR:	1775	£2,275,003	......	£2,275,003
	76	2,962,424	279,292	3,241,716
	77	1,472,996	35,389	1,508,385
	78	1,379,653	......	1,379,653
	79	2,092,133	62,501	2,154,634
	80	1,688,494	99,315	1,787,809
	81	......	......	......
	82	2,823,143	......	2,823,143
	83	1,737,027	......	1,737,027
PEACE:	1784	52,209	......	52,209
	85	862,650	......	862,650
	86	775,824	......	775,824
	87	845,935	......	845,935
	88	383,939	......	383,939
	89	2,435,082	......	2,435,082
	90	1,442,267	......	1,442,267
	91	3,747,307	......	3,747,307
	92	5,776,615	......	5,776,615
WAR:	1793	1,542,154	......	1,542,154
	94	4,818,273	......	4,818,273
	95	4,677,977	......	4,677,977
	96	7,733,480	......	7,333,480
	97	8,179,016	......	8,179,016
	98	5,968,419	......	5,968,419
	99	9,590,856	......	9,590,856
	1800	12,448,135	133,278	12,581,413
	1	11,885,220	264,558	12,149,778
PEACE:	1802	17,961,243	......	17,961,243
WAR:	1803	6,890,541	......	3,890,541
	4	5,609,510	......	5,609,510
	5	5,071,328	......	5,071,328
	6	8,008,627	......	8,008,627
	7	6,014,233	......	6,014,233
	8	4,261,256	653,659	4,914,915
	9	15,412,586	1,119,081	19,895,203

The Epochs.		*The net customs paid into the exchequer.*	*The Money Coined.*
The Restoration	1663, 1669	£ 390,000	By C. II. l.7,524,105 By Js. II. 2,737,637 l.10,261,742
The Revolution	1688	551,141	
The Peace of Ryswick	1697	694,892	by W. III. l.10,511,963
The last years of William III.	1700, 1, 2	1,474,861	
The Wars of Anne	1709	1,257,332	by Anne l.2,691,626
	1712	1,315,423	
The first of George I.	1713, 14, 15	1,588,162	by Geo. I. l.8,725,921
The first of George II.	1726, 27, 28	1,621,731	
The peaceful years	1736, 37, 38	1,492,009	
The War of	1739, 40, 41	1,399,865	by George II. Gold l.11,662,216 Silver 304,360 l.11,966,576
The peaceful years	1749, 50, 51	1,565,942	
The War of	1755, 56, 57	1,763,314	
The first of Geo. III. — WAR:	1760	1,969,934	
	61	1,866,152	
	62	1,858,417	
PEACE:	1763	2,249,604	
	64	2,169,473	
	65	2,271,231	
	66	2,448,280	
	67	2,355,850	
	68	2,445,016	
	69	2,639,086	
	70	2,546,144	
	71	2,642,129	
	72	2,525,596	
	73	2,439,017	
	74	2,567,770	

The great re-coinage of Gold between the 23d of August 1773, and the end of 1777, amounted to l.20,447,002: From the commencement of the reign to August 1773, there were coined, about l.10,000,000: So that, there were coined,

by Geo. III. before the 31st of Dec. 1780,
Of Gold l.30,457,805
Silver 7,126
l.30,464,931

The Epochs.		*The net customs paid into the exchequer.*	*The Money Coined.* Gold.	Silver.	
WAR:	1775	£2,481,031			
	76	2,480,403			
	77	2,229,106			
	78	2,162,681			
	79	2,502,274			
	80	2,723,920			33,367,305
	81	2,791,428	£876,794	£62	
	82	2,861,563	698,074		
	83	2,848,320	227,083		
PEACE:	1784	3,326,639	822,126	202	
	85	4,592,091	2,488,106		
	86	4,076,911	1,107,382		
	87	3,673,807	2,849,056	55,459	
	88	3,780,770	3,664,174		
	89	3,710,343	1,530,711		
	90	3,782,822	2,660,521		
	91	3,952,507	2,456,566		
	92	4,027,230	1,171,863	252	
WAR:	1793	3,978,645	2,747,430		
	94	3,565,117	2,558,894		
	95	3,569,360	493,416	293	
	96	3,651,757	464,680		
	97	4,111,105	2,000,297		
	98	5,599,087	2,967,504		
	99	7,538,355	449,961		
	1800	6,799,755	189,936	90	
	1	5,895,711	450,240	53	
PEACE:	1802	6,087,569	437,018	62	
WAR:	1803	7,179,621	596,445	The silver coinage was prohibited.	2,445,253
	4	8,357,871	718,396		
	5	9,084,459	54,615		
	6	9,733,814	405,105		
	7	9,207,735			
	8	8,797,823	371,744		
	9	10,289,807	298,946		

The total of the present reign £.66,277,489.

The preceding table was first published by Mr. George Chalmers, in his 'comparative strength of the British empire,' p. 207, which extended to 1784. The subsequent years have been filled up from the later panegyrists of the British commercial system, Rose, M'Arthur, Brinsted, and the common periodical publications of the day. M'Arthur supplies the facts to 1800. The books are before me, but I take the table, to save time, from Walsh's Review, vol. 1. The exports and imports of some of the subsequent years, will be found among the other tables I shall present to the reader.

The above statements are the values of exported goods as officially delivered in, on entry, by the exporting merchant. But a custom-house entry has long been a proverbial expression. It has been the great aim of the British ministers since the American war, which ended in 1783, to swell as much as they can, the apparent amount of the commerce of the country. Hence for about fifteen or twenty years past, Mr. Irving the Inspector-general of the Customs, has discovered that the value of the goods exported, was upwards of one third more than the entered value upon which the duties and drawbacks were calculated. As to the inference with respect to the exporting merchant, no one thinks of it or regards it. The calculations of Mr. Irving, are made, I believe from a comparison of Custom-house entries, with the actual amount of East India sales, and with the Convoy duty; and are to a considerable degree well founded; but whether to the extent he reports, I know not, as I do not possess the necessary documents to ascertain the fact. The practice is certainly a very inexpedient one; for it throws great uncertainty on the value of the custom-house documents, and it not only opens a door to double invoices for different purposes, but almost renders them necessary.

The three following tables will illustrate this difference of supposed actual value, from the value declared at the custom-house. The first I copy from Mr. Irving's return of April 4, 1803, the second from his return to the house of commons, on May 16, 1811, ordered to be printed 18 Feb. 1812. The third table is from the Monthly Magazine of July 1812, p. 593.

TABLE FIRST.

An account of the value of all Imports into Great Britain for eighteen years, ending January 5, 1803; exclusive of corn and other grain, and exclusive of importation, from the East Indies and China: together with the difference between the official value and the declared value of British produce and manufactures exported, for as many years of the same period as such an account can be made up.

Y's.	Imports, exclusive of corn and other grain, and exclusive of importations from the East and West Indies. Official value.			British produce and manufactures exported. Official value.			Real or declared value.
	£	s	d	£	s	d	£
1785	12,939,536	16	10	11,081,810	16	5	
1786	12,053,839	13	5	11,830,372	18	11	
1787	12,761,245	10	5	12,053,900	3	5	
1788	13,807,708	8	9	12,724,719	17	9	
1789	13,879,465	9	11	15,779,506	2	6	
1790	14,924,222	15	8	14,921,084	9	7	
1791	14,463,725	18	11	16,810,018	16	4	
1792	16,005,657	18	7	18,336,851	6	11	
1793	14,165,443	1	4	13,892,268	17	7	
1794	16,482,673	10	11	16,725,492	16	2	
1795	19,010,233	8	0	16,338,213	2	2	
1796	17,441,036	19	10	19,102,220	3	11	
1797	15,803,883	7	8	16,903,103	6	1	
1798	18,862,188	13	7	19,672,503	0	9	33,148,692
1799	21,386,240	17	10	24,584,213	0	10	38,942,498
1800	22,720,664	11	8	24,304,283	13	6	39,471,203
1801	24,145,500	12	0	25,699,809	6	1	41,770,344
1802	24,436,481	14	11	27,012,108	3	10	48,500,683
1803	—	—	—	—	—	—	—
1804	—	—	—	—	—	—	—

TABLE SECOND.

British	Official value.	Real value.
Imports in 1805	30,344,628	63,582,146
1806	28,835,907	50,621,707
1807	28,854,658	53,500,990
1808	29,629,353	55,718,698
1809	33,772,409	59,851,352
1810	41,136,135	74,538,061

	Official value.	Real value.	Customs received.
exports in 1805	34,308,545	51,109,131	
1806	36,527,[illegible]64	53,028,881	9,456,255
1807	34,566,572	50,482,661	9,573,060
1808	34,554,267	49,[illegible]69,[illegible]46	9,214,131
1809	5[illegible],286,900	66,017,712	10,532,989
1810	45,869,860	62,702,409	10,773,869

Annual Register, 1809, *page* 345.

I have no means of filling up this table to the present time: excepting as to the year 1811, when the real value of the exports amounted to about 44 millions as appears by the following table. From the preceding, it should seem, that if we add to the *official* value about one half its amount, we shall approximate to what is considered as the *real* value of goods exported.

TABLE III.

An Account of the real value of Exports from Great Britain in the years 1805, 1806, 1807, 1808, 1809, 1810, and 1811, respectively—distinguishing generally the countries to which the goods were exported.

YEARS.	Continent of Europe.	Ireland and Isles Guernsey, Jersey and Man.	ASIA.	AFRICA.	United States of America.	Other parts of America and the W. Indies.	TOTAL.
	pounds	pounds	pounds.	pounds.	pounds.	pounds.	pounds.
1805, ...	20,435,940	6,400,363	3,111,748	1,136,955	11,446,939	8,557,186	51,109,131
1806, ...	17,547,243	5,813,650	3,259,834	1,655,042	12,865,551	11,887,501	53,028,881
1807, ...	15,420,514	7,032,272	3,555,392	1,022,745	12,007,942	11,353,796	50,482,661
1808, ...	13,983,123	7,971,694	3,718,813	820,194	5,302,863	18,173,056	49,969,746
1809, ...	27,190,337	7,565,599	2,990,440	976,872	7,460,768	19,833,696	66,017,712
1810, ...	24,224,567	5,765,464	3,117,075	693,911	11,217,683	17,683,707	62,702,409
1811, ...	18,537,204	7,210,699	3,063,971	409,075	1,874,917	12,843,754	43,939,620
Annual average of 3 ys. ending with 1807,	17,801,232	6,415,428	3,308,991	1,278,248	12,136,811	10,599,514	51,540,224
Ann. average of 4 years ending with 1811,	20,983,808	7,128,364	3,222,575	725,013	6,464,059	17,133,553	55,657,372

WILLIAM IRVING, Inspector-General of Imports and Exports.

Custom-House,
London, 28*th April*, 1812.

Month. Mag. for July 1812, *p.* 595.

It will be observed that there are differences in the amounts of these tables, from each other, and from that which Walsh has given from the authors, I have cited. I do not know how to account for the differences, but I regard Mr. Irving's statements as entitled to superior credit.

Since the American peace of 1783, it has been the fashion of all the ministers of Great Britain, from Pitt to Percival, at the annual opening of the budget, to dwell with almost exclusive interest on the state of the commerce of the country, on the vast and increasing amount of exports and imports, and the balance of trade. This seems to have arisen not merely from what I conceive false views of the relative importance of foreign commerce, but also from the necessity of conciliating the prejudices of the monied interest. This bias in favour of commercial statements appears to me to have been carried by Mr. Pitt, and Mr. Percival particularly, to a morbid excess. Even during the periods of war, the wonderful encrease of British commerce has been the theme of ministerial exultation; but the minister never thought fit to enter into any analysis of the items. It seemed as if the most effectual method ever discovered of encreasing the trade of the country, was to go to war with all the world, and contrive that no market whatever should be open to British goods. The success of these legerdemain calculations, was truly astonishing. The minister borrowed for instance twenty millions sterling: he laid out the greatest part of it, in cloathing, arms, provisions, &c. &c. for the use of the navy and army. The merchants and manufactures among whom this money was expended, entered the goods in the usual course for exportation, and all the other exports on account of government, were also entered at the custom house; these entries, swelling the bulk of export, are gravely used as evidences of the great encrease of foreign trade! We cannot therefore, if this account of the matter be true, as I believe it to be, consider the gross statements of export and import of that country, as furnishing any accurate knowledge of the real state of foreign trade. I shall be glad to receive any *authentic* refutation of this view of the subject, if any person knowing otherwise, will furnish *the facts*: but I know this has been, and I believe it continues to be the case.

OF THE TONNAGE OF GREAT BRITAIN.

British Navy. The following extract of a letter, addressed to Mr. Percival by lord Melville, on the subject of the establishment of a naval arsenal at North fleet, presents within a small com

pass a striking view of the progressive increase of the British navy:

"The following short statement will remind you of the establishment of the different royal dock yards now existing in the kingdom. They are six in number, Deptford, Woolwich, Chatham, Sheerness, Portsmouth and Plymouth.

"Deptford was built in the reign of Henry the VIII. under whose sway, history tells us, this country possessed the first fleet composed of ships of war, belonging to the king: although I have heard that some archives, recently discovered in the tower, prove the existence of a fleet of that kind in the reign of the preceding monarch, Henry VII.

"Woolwich yard was formed under the auspices of the same monarch.

"Chatham was founded by queen Elizabeth, where the gun-wharf now is, and where there was only one small dock: but that being too confined a spot, it was removed about the year 1622 to its present situation.

"Sheerness was formed in the reign of Charles II.

"Portsmouth by Henry VIII. being the third dock yard founded by him.

"Plymouth by William III. about the year 1694, and in 1698 money was voted by the house of commons for completing it.

"The progressive advance of our navy, will appear by attending to the following recital of its tonnage at different periods, from the reign of Henry VIII. to the present time.

	Year	*Tons about.*
At the death of Henry VIII	1547	12,400
Edward VI	1553	11,000
Mary	1558	7,000
Elizabeth	1603	17,100
James I	1625	19,400
Rebellion	1641	22,400
Charles I	1649	uncertain
At the restoration	1660	57,460
Death of Charles II	1685	103,558
Abdication of James II	1688	101,900
Death of William III	1702	159,000
Anne	1614	167,170
George I	1727	170,860
George II	1769	321,200
On the 31st December,	1788	4 3,660
- - - - - - - - - -	1806	776,000
- - - - - - - - - -	1809	800,000

"Thus it appears, that notwithstanding the vast increase of our navy not a single dock yard has been added to it since the reign of William III. about a hundred and nineteen years ago, at which time the tonnage of the naval force of this kingdom amounted to near 160,000 tons: it is now near 800,900 tons, or about five times as large."

The following statement is the amount and disposition of the British navy up to January 1, 1812. At sea, 115 of the line; 8 from 44 to 50; 126 frigates; 97 sloops; 5 bombs; 121 brigs; 32 cutters; 52 schooners—total 527. In port and fitting, 32 of the line; 8 from 44 to 50; 28 frigates; 38 sloops; 1 bomb; 29 brigs; 6 cutters; 21 schooners—total 162. Guard ships, 4 of the line; 1 fifty; 4 frigates; 5 sloops—total 14. Hospital ships, &c. 31 of the line; 3 of 50; 3 frigates—total 37. Total in commission, 187 of the line; 20 from 44 to 50; 161 frigates; 140 sloops; 6 bombs; 150 brigs; 37 cutters; 73 schooners——total 740. Ordinary and repairing for service, 70 of the line; 14 from 44 to 50; 59 frigates; 38 sloops; 6 bombs; 13 brigs; 2 schooners—total 202. Building, 31 of the line; 2 of fifty; 14 frigates; 5 sloops—total 52, forming the grand total of 994 British vessels of war.

Comparative strength of the different Naval Powers, 1813.

British Naval Force.—At sea, 79 ships of the line: nine from 50 to 44 guns—122 frigates—77 sloops and yachts—4 bombs, &c.— 161 brigs—54 cutters—52 schooners, &c.——In port and fitting, 30 of the line—11 from 50 to 44 guns—29 frigates—18 sloops—4 bombs, &c.—86 brigs—6 cutters—11 schooners, &c. ——Hospital ships, prison ships, &c. 28 of the line—2 from 50 to 44—2 frigates—1 yacht——Ordinary and repairing for service, 77 of the line—10 from 50 to 44 guns—70 frigates—37 sloops—3 bombs—11 brigs—1 cutter—2 schooners.——Building, 29 of the line—4 from 50 to 44 guns—12 frigates—5 sloops, &c.—3 brigs——Making a grand total of 1545 vessels.

Russian Navy.—53 sail of the line—34 frigates—59 cutters, brigs, &c.—smaller vessels, 226, carrying in all 4,428 pieces of cannon.—In this estimate are included ships of every class and condition, from a first-rate to a gun-brig; those that are building, under repair, and laid up in ordinary as unserviceable, as well as those that are in commission, and fit for immediate service.

SWEDISH NAVY.—The Swedish fleet consists of 12 sail of the line, eight frigates, besides cutters, gun boats, &c. and there are two ships of the line and three frigates building.

PORTUGUESE NAVY.—The Portuguese have eight sail of the line, three frigates, and four sloops, at the Brazils—At Lisbon there are some ships of war, but they are chiefly unfit for service.

DANISH NAVY.—The present naval force of Denmark consists of four ships of the line, two frigates, and about 120 gun-boats. There are two ships of the line and three frigates on the stocks. Their maritime operations are chiefly carried on by flotillas of gun brigs, which carry heavy metal, are well manned, manœuvred, and fought; and, in a calm, are formidable even to ships of war.

UNITED STATES NAVY.—The republican navy, at present, consists of the following frigates:—Constitution, 44, Captain Hull; United States, 44, Captain Decatur; President, 44, Commodore Rogers; Chesapeake, 36; New-York, 36; Constellation, 36; Captain Bainbridge; Congress, 36, Captain Smith; Boston 32; Essex, 32, Captain Porter; Macedonian, (late British,) 38; the John Adams corvette: Hornet sloop, of 16 guns; Syren, Argus, and Oneida brigs, of 16 guns; Vixen, Enterprize, and Viper schooners, of 12 guns; 170 gun boats, stationed at New Orleans: and the Vengeance, Ætna, Vesuvius, and Spitfire bombs.

FRENCH NAVY.—In the various ports of France, Holland, and Italy, the French have 65 sail of the line, and 61 frigates, ready for sea; and 32 sail of the line, and 26 frigates, building and fitting out; so that in a short time we shall have opposed to us, under French colours, a numerical force of 97 sail of the line, and 87 frigates: but even the ships which are pretended to be ready for a start, particularly those in the Scheldt, are very badly manned; an evil for which the enemy does not possess any practicable remedy.

13th January, 1813.

VESSELS OF WAR.

A general view of the dimensions of the most approved ships of each class in the British navy. Prepared from authentic papers, for the Register. (Niles.)

Note.—Fractions omitted. When more than a half, added, when less than a half, unnoticed.

DIMENSIONS OF SHIPS AND THEIR APPURTENANCES.		Of 100 guns.	Of 90 guns.	Of 74 guns.	Of 64 guns.	Of 50 guns.	Of 44 guns.	Of 32 guns.	Of 28 guns	Of 20 guns.	Of 14 guns.
Length of the gun deck	*feet*	186	177	169	158	146	140	126	118	108	96
Do. of the keel for tonnage	do	151	146	138	129	119	115	103	97	89	78
Extreme breadth -	do	52	49	46	44	40	37	35	34	30	27
Depth in the waist -	do	6	5*h*	6	6	5	5	5	5	5	4*h*
Do. in the hold - -	do	21*h*	21	20	19	17*h*	16	12	10*h*	10	12
Burthen - -	*in tons*	2162	1871	1620	1336	1045	879	690	586	429	300
Foremast—length -	*yards*	34*h*	33*h*	32	30	27	26	25	24	21	19
thickness	*inches*	34*h*	33*h*	32	30	27	23	22	21	19	17
Main-mast—length	*yards*	39	37	36	33	31	29	28	27	24	21
thickness	*inches*	39	37	36	33	29	26	24*h*	22	22	18
Mizen mast—length	*yards*	34	33	31	29	26	25	24	20	18	17
thickness	*inches*	23	22	21	20	18	17	16	16	14	12
Fore top mast——length	*yards*	21	19	19	18	16	15	15	13	12	11
Main top mast do	do	23	20	22	19	18	18	17	16	14	12
Mizen top mast do	do	16	16	15	14	13	13	13	12	11	9
Fore top gallant mast do	do	10	9	9	9	8	8	7	8	8	5
Main top gallant mast do	do	11	11	11	10	9	9	8	9	8	6
Mizen top gallant mast do	do	8	8	8	7	7	7	6	6	5	4
Bowsprit - - do	do	24	24	23	20	18	17	17	17	15	13
thickness - -	*inches*	37	36	34	31	28	26	25	23	23	18
Flying gib boom—length	*yards*	17	17	16	15	13	13	12	12	11	9
Fore yard - do	do	30	28	28	26	24	23	21	22	19	16
Main yard - do	do	34	32	32	30	28	27	25	25	22	18
Mizen yard - do	do	29	27	29	27	25	24	22	20	20	8
Guns—gun deck -	*no.*	30	28	28	26	22	20	26	24	20	14
Metal -	*pounds*	42	32	38	24	24	18	12	9	9	6
Middle deck -	*no.*	28	30								
Metal -	*pounds*	24	18								
Upper deck -	*no*	30	30	28	26	22	20				
Metal -	*pounds*	12	12	18	18	12	9				
Quarter deck and forecastle	*no.*	12	2	18	12	6	3	6	4		
Metal—weight	*pounds*	6	9	9	9	6	6	6	3		

A 42 pounder is 9 feet 6 inches long, 6 1-2 in the bore, and weighs 65 *cwt.*

32	do	9	6	do	6	50
24	do	9		do	5 1-2	48
18	do	9		do	5	39
12	do	9		do	4 1 2	34
9	do	7	6	do	4	25
6	do	6		do	3 1-2	16
3	do	4	6	do	3	6

☞ The foregoing table is formed and inserted for the purpose of giving a *general* idea of the dimensions and force of a ship, on hearing her *rate* mentioned in the newspapers. But their actual force in guns is commonly from a fourth to a third more than they are rated—and their weight of metal and many other particulars, differ widely from the rules of the admiralty, being governed by various *particular* circumstances, in the make or construction of the vessels.

A 74 gun ship is calculated in England to consume the timber of 50 acres of oak land. The *modern built* vessels of the British navy do not last, on an average, more than nine years, owing to the want of proper seasoning. Pine wood will not last more than six years. At present the English resort to the Teek-wood of the East Indies.

An account of the number of vessels, with the amount of their tonnage, and the number of men and boys employed in navigating the same, (including their repeated voyages) which entered inwards and cleared outwards, at the several ports of Great Britain, from and to all parts of the world, in the years 1806, 1807, 1808, 1809, 1810 and 1811—distinguishing British from foreign.

YEARS.		BRITISH.			FOREIGN.			TOTAL		
		Ships.	Tons.	Men.	Ships	Tons.	Men.	Ships.	Tons.	Men.
Inwards.	1806	12,110	1,482,412	88,963	3,792	612,800	31,346	15,902	2,095,212	120 309
	1807	11,213	1,436.667	84,997	4 087	680,144	32,488	15,300	2,116,811	117,485
	1808	11,303	1,311,966	82 617	1,926	283,657	15,540	13,231	1,595,623	98,157
	1809	12,656	1,539,573	95,796	4,922	759,287	38,285	17,578	2 298,860	134,081
	1810	13,557	1,609,088	102,900	6,876	1,176,243	66,094	20,433	2 785,331	162,994
	1811	12,908	1,522,692	94,740	3,216	687,180	34,157	16,124	2,209,872	128,897
Outwards.	1806	12,239	1,485.725	94,513	3,457	567,988	29,616	15,696	2,053 713	124,129
	1807	11,428	1,424,103	89,720	3 846	631,910	31,411	15,274	2,056,013	121,131
	1808	11,917	1,372,261	89,671	1,892	282,145	15,671	13,809	1,654,406	105.272
	1809	12,499	1,531,152	102 523	4,530	699,750	37,256	17,029	2,230,902	139,779
	1810	15,090	1,624,120	107.713	6,641	1,138,527	60,870	19.731	2.762,647	168,583
	1811	12,774	1,507,333	96,739	3 350	696,232	37,262	16,124	2,203,585	134,001

J. E. WILLOUGHBY, Bec. General.

Custom-House,
London, 28*th April*, 1812,

It appears from some documents that I have mislaid, that in the fall of the year 1813, the number of British merchant vessels was near 23,000.

BRITISH STOCK OR FUNDS.

These are denominations of public debt, and the taxes appropriated by parliament to pay the interest of that public or national debt, and support the current expences of government; these have at different times been *funded*; that is, classed, arranged, and made permanent under different names, as temporary expedience required. Such as three per cents 1726: three per cents consol (consolidated annuities); three per cents reduced; three per cents deferred stock; three per cents south sea of 1751; three per cent. old south sea annuities; three per cent. new south sea annuities; three per cent. imperial annuities; four per cent. consols. Five per cent. navy annuities; five per cent. stock of 1797, and 1802; five per cent. Irish. Old annuities; long annuities; short annuities; Irish annuities; imperial annuity; south sea stock. The Bank stock, and India stock, India annuities, India bonds belong exclusively to those two chartered companies respectively.

Thus it appears that some of these funds, consist of annuities payable to the public creditor or stock holder, for ever: and others, of annuities that expire at certain periods.

When three per cent. consols, or any other three per cent. perpetual annuities can be purchased at 60; four per cents at 80; five per cents at 100; Bank stock yielding a dividend of seven per cent. at 140; India stock yielding 10½ dividend, at 210, then does the purchaser get five per cent. or legal interest, for his money. Whenever the three per cent. consols for instance, which is the largest stock in amount, fall below 60, the stock is manifestly depreciated by national circumstances. Indeed, when legal interest is at five per cent. three per cents ought to fetch 80, owing to the ease and certainty, with which the interest is receivable.

The funds existing in Sir R. Walpole's time, were then formed (1715, and 1716) into three general funds, the *aggregate* fund; the *south sea* fund and the *general* fund: to which in 1716 Sir Robert added the *sinking* fund, of which I shall speak separately. To these funds certain taxes were respectively annexed, the produce whereof was invariably to be applied to the payment of the interest of that fund, which thus formed a mortgage on the tax.

The following account from 1 Niles's Reg. 261, is tolerably accurate.

NATIONAL DEBT—EXPENDITURE—TAXATION.

National Debt.

When queen Anne came to the throne in 1701, the debt was	l.16,394,702
When George I. came to the throne in 1714	54,145,362
When George II. came to the throne in 1727	52,092,235
When George III. came to the throne in 1760	146,682,844
At the close of the American war the debt was (1784)	257,213,043
At the close of the war against "revolutionary France," (1801)	579,911,447
January 5, 1810	811,893,082

From a late debate in the British house of Lords, (1813), on a motion made by lord Lauderdale to enquire into the alarming state of the currency of that nation, we learn the following interesting facts, viz:

1. That three years ago, the war cost the British government 100 millions—next year, 104 millions—and last year, 112 millions sterling!

2. That, in the course of the present year, 50 millions have been added to the national debt.

3. That, in the year 1813, the bank of England bills, then in circulation, were only 12 millions; now, they amount to 43 millions.

4. That government, besides interest on the national debt, pays to the bank of England an *extra* interest of nearly two millions on their exchequer bills.

5. That in July last, an ounce of Portuguese gold, formerly 3l. 17s. 6d. now brings 5l. 5s. in bank paper. A silver dollar, formerly worth 4s. 6d. with the new stamp, now brings 6s. 9d.

6. That paper currency has depreciated 35 per cent.

7. That, some years ago, there were annually brought from New Spain between thirty and forty millions of dollars; now, only between seven and eight millions.

Funded and unfunded debts of Great Britain and Ireland on the 1st of January, 1813.

Great Britain - - -	l 812,013,135	8	11½
Ireland - - -	94,926,454	7	8¼
Total,	l 906,939,589	16	8¼

An account of the total amount of the capital of the unfunded debt of Great Britain and Ireland, up to the 5th of January, 1813.

Great Britain - - - -	*l* 54,055,632	17	11
Ireland - - - -	2,342,215	18	11
	l 56,397,848	16	10

An account of the total money raised in the year ending the 5th of January, 1813; specifying the sums raised by taxes and by loan.

RAISED BY TAXES.

GREAT BRITAIN.

Paid into the exchequer on account of every branch of public revenue or income (except lotteries, and the interest, &c. of the Irish debt)	*l* 58,790,361,	7	4½
Ditto on account of lotteries - -	942,537	17	8
Payments in anticipation of exchequer receipts: drawbacks, discounts, charges of management, &c. paid out of gross revenue	6,025,148	9	0
Payments out of nett produce, applicable to national objects	1,036,597	2	5¼
Total,	*l* 66,794,644	16	5¾

IRELAND.

Paid into the exchequer on account of every branch of public revenue or income (except the interest, &c. of the Irish debt.)	*l* 4,779,857	13	9
Payments in anticipation of exchequer receipts: Drawbacks, discounts, charges of management, &c. paid out of gross revenue	1,006,701	1	9
Payments out of nett produce, applicable to tional objects	213,214,	14	10
Total,	*l* 5,999,771	15	4

RAISED BY LOAN.

GREAT BRITAIN.

By increase of national debt—By loan	*l* 29,268,586	16	8
Retained by the bank for receiving loans and lotteries	19,031	14	0

By exchequer bills funded	5,431,700 0 0
By increase of exchequer bills, outstanding	3,914,600 0 0
Total, *l*	38,633,918 10 8

IRELAND.

By increase of national debt—By loan	*l* 1,396,615 7 8
By increase of exchequer bills, outstanding	478,579 9 8
Total, *l*	1,875,194 17 4
Grand total, *l*	113,303,529 19 9¼

RICHARD WHARTON

Whitehall Treasury Chambers, April 14, 1813.

As the greater part of the debt bears only *three per cent. per annum*, and *l* 100 of its *stock* will produce no more than from 60 to *l* 65 in *money*, the British financial writers estimate its *real* amount to be about 500 millions, *because it might be purchased for that sum in cash.*

The following facts will explain to the reader why such great quantities of stock have been created at such low rates of interest.

In 1806, the British government borrowed eighteen millions of money—but the stock created by it was exactly *l* 29,880,000; thus—they gave *l* 70 stock three per cent. reduced; *l* 70 three per cent. consols.; and *l*10, five per cent. navy; making *l*150 stock for *l*100 money; besides, there was *l* 2,880,000 *more stock created than the money produced, at this rate.* Whether this was a *bonus* to the lenders, we are unable to say—the facts are as stated.

Again—in 1808, *l* 10,500,000 were raised—for every *l* 100, the lenders agreed to take *l* 118 3*s* 6*d*. in the four per cents.—making a stock of *l* 12,408,475, and so bearing a *real* interest of nearly five per cent. besides the usual *discounts* and *premiums*.

The foregoing may serve to give a general idea of the nature of the British funds. But we do not pretend to understand the subject minutely, or comprehend clearly, the financial operations of this government. They are surrounded by mystery; and completely known only to the few who "gamble" in them. The annexed explanation of terms will assist the reader to feel the *monied pulse* of the nation, on seeing the price of stocks quoted in the newspapers:

DESCRIPTION OF THE PUBLIC FUNDS.

Navy five per cent. annuities, produced from about fifty millions of stock, partly formed out of navy bills, converted in 1784, into a stock bearing interest at five per cent. whence the name.

Four per cent. consolidated annuities, produced from the same quantity of stock as the last, bearing interest at four per cent. as the title indicates; these annuities are called consols, or consolidated, from the stock having been formed by the consolidation of several debts of government.

Three per cent. reduced annuities, produced by about 170 millions of stock formed from several debts, that originally bore a higher rate of interest, but which, on various conditions, has been reduced to the rate which the name of the stocks express.

Three per cent. consolidated annuities produced by above four hundred millions of stock, in part formed by the consolidation of several stocks, bearing interest at three per cent.

N. B. When the word *consols* is indefinitely used it is always understood to mean these annuities.

Three per cent. imperial annuities, produced by above eight millions of stock created by loans to the emperor of Germany, with the security of the interest being paid by the government of this country, whenever the emperor should fail his engagement.

Five per cent. Irish annuities, produced by about two millions of stock formed by loans for the use of Ireland, before the union.

Bank stock, is a capital of nearly twelve millions with which the company of the bank has accommodated government with various loans, and with which they carry on the banking business, purchase bullion, &c. The dividends on bank stock are now ten per cent.; so that the profits of the company are near twelve hundred thousand pounds per annum.

India stock, forms the trading capital of the East India company; this stock (consisting of six millions) produces an annual dividend of $10\frac{1}{2}$ per cent.

South sea stock and annuities consist of, or are produced from a capital of nearly twenty millions. The greatest part of this is lent to government, for which the company receive 3 per cent. but from the increase of other profits the dividend to the proprietors is $3\frac{1}{2}$ per cent.

The terminable annuities are,

Bank long annuities, so called from the annual payment being from their origin made payable at the bank, and from their being granted for a greater length of time, than other terminable annui-

ties.—These annuities extend to the beginning of the year 1806, and the annual payments are about eleven hundred thousand pounds.

Imperial short annuities, formed in the same manner, and upon the same conditions, as the imperial 3 per cent. annuities: they extend to May 1809.

Besides the permanent loans to government, which have created a perpetual and terminable annuities, various sums have been raised from time to time, as temporary loans, on what are called Exchequer bills, from their being made payable at the treasury of the exchequer.

Exchequer bills, are issued for different hundreds or thousand of pounds, and bear an annual interest of $3\frac{1}{2}$ per cent. per diem, from the day of their date to the time when they are advertised to be paid off.

Navy bills, are merely bills of exchange, drawn at 90 days date, and are given by the commissioners of the navy for the amount of supplies, for the use of that department, and the interest upon those amount to 3 per cent. per diem.

India bonds are issued by the East India company, and bear interest at 5 per cent. per annum.

Omnium, is a term denoting the different stocks formed by a loan, while any part of the loan remains unpaid. For example, suppose 20 millions of money were to be raised, and for every 100*l* in money, are to be given 100*l* stock in the 3 per cents. 50*l* stock in the 4 per cents. and 6s 3d per cent. in the long annuities; then if any person engage to advance 10,000*l* in money, upon paying the first instalment, (for the money is usually advanced at the rate of about ten per cent. per month, until the whole is paid,) he will receive three receipts, which separately contain an engagement to answer to the person possessing them 10,000*l* stock in the three per cents. 5,000*l* stock in the four per cents. and 31*l* 10*s*, stock in the long annuities, upon the whole of the instalments being paid, at or before the appointed time—While these three receipts are sold together, and before the whole of the instalment has been paid they are called Omnium, as they are made up of all, or of several of the stocks.

Scrip, is a term given to each of the receipts of the omnium, they are sold separately: thus in the foregoing supposition, if the receipt containing the engagement to transfer the 10,000*l*. in the three per cent. be sold without the other two receipts, this would be called a sale of script. Immediately the whole of the instalments upon any script is paid, the transfer of the stock is made to the per-

son who holds it, and there is usually a discount allowed for any prompt payment.

N. B. When the stock created by any loan is formed in only one sort of stock, there is properly speaking no omnium; though, then by a misnomer, the script receipt is called by that name.

The prices of the stocks, &c. are exhibited in the lists that are published, in this manner.

The value of any perpetual annuity, thus:

Three per cent. consols, 63 1-8, 64 3-4, 1-2. which

Signifies, that the value of 100*l*. stock of these annuities sold on the day this price is given, for 63*l* 2*s* 6*d* in money at the beginning of the market, that this stock rose to 64*l* 15*s* and left off at 64*l* 10*s*.

The value of any terminable annuity, thus:

Bank Long Annuities, 16 3-8, 16 1-6.

Signifying, that any annual payment of these annuities was worth 16 3-8 years purchase at the beginning, and left off at 16 $\frac{1}{16}$ years purchase at the end of the market.

The value of either exchequer bills, or India bonds, thus:

Exchequer bills, 2 a 4 premium, or India bonds, 1 pr. 2 discount.

This signifies that every 100*l*. in exchequer bills bore a premium of 2*s* at the beginning, which advanced to 4*s* in the end of that day; and that every 100*l*. in India bonds, sold at first at 1*s*. premium, and afterwards sold at 2*s* discount.

The value of omnium is expressed thus,

Omnium 3½ premium;

And signifies that every 100*l* of omnium, sold at a premium 3*l* 10*s*.

NATIONAL EXPENDITURE.

When queen Anne came to the throne, 1701, the whole annual expenditure, including the interest on the national debt, was	*l* 5,610,987	*peace.*
When George I. came to the throne (1714) just after queen Anne had been at war 11 years	6,663,581	*peace.*
When George II. came to the throne, 1727	5,441,248	*peace.*
When George III. came to the throne, 1760	24,456,940	*war.*
At the end of the American war, and beginning of Pitt's administration, 1784	21,657,609	*peace.*
At the latter end of the war against "revolutionary France," 1801	61,278,218	*war.*
For the year 1809	82,027,288	*war.*
1810	83,099,186	*war.*

TAXATION.

When queen Anne came to the throne in 1701, the yearly amount of taxes was	*l* 4,212,353
When George I. came to the throne in 1714	6,762,643
When George II. came to the throne, 1727	6,522,540
When George III. came to the throne, 1760	8,744,682
After the end of the American war, 1784	13,300,921
At the close of the war against "revolutionary France," 1801	36,720,071
For the year 1809	70,240,229
1810 (nett revenue)	70,235,792

FUNDED DEBT.

The total amount of the capital of the funded debt of the United Kingdom, on the 1st of January, 1812, was

Great Britain - - -	*l* 747,429,339	11	3¼
Ireland - - - - -	61,274,250	0	0
Emperor of Germany - -	7,502,633	6	8
Portugal - - - - -	895,522	7	9
	l 817,101,745	5	8¼

The unfunded debt of Great Britain, on the 5th of January, 1812, was

Exchequer Bills - - - -	*l* 41,491,800	0	0
Navy ditto - - - - -	7,883,890	10	4
Ordnance Debentures - -	1,078,476	5	4
Loan ditto			
	l 50,454,166	15	8

That of Ireland was, Exchequer Bills 1,840,787*l*. 17*s*. Loan Debentures 2,225*l*. making 1,843,012*l*. 10*s*. The total for the United Kingdom was 52,297,179*l*. 5*s*. 8*d*.

The total amount of money raised in the year ending January 5, 1812, was, permanent taxes, 35,458,269*l*. 4*s*. 9½*d*. Interest on account of Ireland and Portugal; surplus exchequer fees, imprest monies, and tontine money, 3,003,476*l*. 19*s*. 5½*d*. Duties to discharge three millions of exchequer bills, 2,827,785*l*. 18*s*. 1¼*d*. War taxes, 22,3[illegible]*l*. [illegible]*s*. 5¾*d*. Money paid on account of loans, 19,638,379*l*. 3*s*. 9*d*.; and on account of lotteries, 922,136*l*. 8*s*. The total, 81,241,697*l*. 7*s*. 7¼*d*.

The amount of exchequer bills outstanding on the 5th of April, 1812, was 43,406,800*l*. of which those issued since the 1st of February, 1812, amount to 9,378,500*l*.

The amount of the land-tax assessed in respect of land, in the year ending March 25, 1811, in the counties in England and Wales, was 1,226,321*l.* 5*s.* 2¼*d.* The amount then redeemed was 634,365*l.* 8*s.* 1¼*d.* In Middlesex, which pays more than double any other county, the amount assessed was 171,665*l.* 1*s.* 0½*d.* and the amount redeemed, 61,914*l.* 5*s.* 9*d.*

The stamped dollars issued by the bank of England from the 19th of February, 1811, to the 13th of April, 1812, inclusive, at five shillings each, amounted to 424,584; and at five shillings and six pence each, to 21,340; the number of silver tokens for the same period, at three shillings each, to 722,446; and at eighteen-pence each, to 3,361,171: the whole making a value of 1,447,469*l.* 4*s.* 6*d.*

The number of re-issuable promissory notes, stamped in England during the year ending the 10th of October, 1811, was 3,563,788. Of these 2,702,563 did not exceed a guinea in value, and 1632 were from 50*l.* to 100*l.* in value. This account does not include stamps consigned to distributors.

The number of stamps for promissory notes re-issuable from February 16, 1811, to the 5th of April, 1812, amounted to 3,323,180. Of those exceeding in value 50*l.* and not exceeding 100*l.* the number was 1396. The total number was 4,455,556.

The number of licences renewed to existing bankers in the year ending October 10, 1811, for the issue of promissory notes, payable on demand, was 696, and to new banks, 82. From the 11th of October, 1811, to the 20th of April, 1812, the number of renewed was 735; and from October 11, 1812, granted to new banks, 52. In Scotland, during that period, the whole number was 50. The total was 824 for the year 1811, and 838 for the year 1812, which last is the number of private bankers in Great Britain for that year (1812).

The following is an account of the total amount of money raised for the public service, in each of the years from 1791 to 1810 inclusive.

	Raised in each Year.		
1791	£18,863,594	19	2¼
1792	18,8[illegible]2,465	5	7¾
1793	22,050,898	8	2
1794	32,102,168	9	4½
1795	37,641,736	12	2¾
1796	60,969,839	8	1¹
1797	49,931,120	0	8¼
1798	50,889,326	13	5¾

Michaelmas 1798 to 5th Jan. 1799	10,232,969	16	9
1799	57,434,677	7	3
1800	58,630,216	8	4½
1801	75,743,475	4	10
1802	68,563,718	4	2¼
1803	55,821,209	10	0¾
1804	64,947,614	4	5¾
1805	81,167,978	4	5¼
1806	79,736,321	6	8
1807	81,102,138	10	10¾
1808	82,225,110	10	7
1809	93,192,742	10	8
1810	97,948,034	0	1¼

CONSOLIDATED FUND: WAR TAXES.

During the war in which Great Britain has been engaged with the French republic and the French empire, the then existing, and certain other new taxes, were considered by Mr. Pitt as needful to be permanently continued on the people, to answer the public necessities; but certain other taxes which the supposed temporary exigencies of the war called for, were laid, on the expectation that when the war ceased, these taxes would cease also: the first class of taxes, were formed into one fund called the consolidated fund; and consisted of the customs, the excise, the assessed taxes, the land tax, &c. which forming one class of income, is exclusively appropriated to certain payments, of which the dividends, or interest of the national debt is the chief and heaviest charge: If this fund yields more than sufficient to satisfy the demands charged upon it, the excess is brought forward in the budget of the next year, under the head of "surplus of the consolidated fund" as part of the ways and means of raising the supplies wanted for the year. If not, then the deficiency takes its place, not among the Ways and Means, but among the Supplies. The consolidated fund for 1810 produced 42,286,152*l* 18*s* 11*d*. and charges were 35,296,313*l* 10*s* 9*d*. leaving a surplus of 6,979,739*l* 8*s* 2*d*. The same fund up to 5 January, 1812, produced but 40,917,135*l* 18*s* 4*d*. The charges were 36,801,993*l* 18*s* 9*d*. leaving a surplus of 4,115,841*l* 19*s* 6*d*. The decrease was in the customs.

The other taxes which were laid on for the support of the war, under a promise of being temporary, and to be taken off when the war is ended (that is ad græcas calendas) are called the *war taxes*. These consist of additional customs, excise, property tax. &c. In 1811 they produced 22,393,063*l* 18*s* 5*d*.

THE SINKING FUND.

In 1716 Sir Robert Walpole at the suggestion of Earl Stanhope, proposed that the surplus of the aggregate, the south sea, and the general funds, should go to another fund called the sinking fund, and be applied to the repurchase and redemption of the national debt. Sir Robert Walpole however in 1733 wanting half a million Sterling, proposed to take it from the sinking fund, under two pretences, 1st, that the country would not support an additional land tax, and 2dly, that the purchasing up so much stock and taking it out of market, was a greater defalcation from the circulation of the kingdom than the monied interest could well bear. He prevailed; and depredations were committed on this fund by him and subsequent ministers, till it was rendered nearly inefficient.

Soon after the close of the American war, Dr. Price proposed to Mr. Pitt, the establishment of a sinking fund, which under the controul of commissioners operating perpetually on the national debt, might produce an interest approximating to compound interest, while the nation paid its creditors at the rate of simple interest only. To aid this, he proposed that when loans were required, the debt should be created by paying large interest on small sums, rather than by borrowing at a low interest, increase the amount of the capital borrowed. Unfortunately, Mr. Pitt through timidity as a financier, rejected the last proposal: but in 1786 he established the modern sinking fund, 1st, by appropriating a capital of a million a year, and then by adding to it divers surpluses of taxes. Lord Lauderdale has objected to the principle of the sinking fund, as taking out of the productive capital of the nation, so much as it redeems of the debt, but I do not see the force of his reasoning. In my mind, this fund faithfully applied during a long continuance of peace, would go far to annihilate the debt of England, enormous as it is: but unfortunately, the national burthens increase in far greater proportion, than this fund can diminish them. At the close of the year 1812, it had redeemed of the national debt about 222 millions; and the fund to be appropriated to the same purpose, for the next year, would be upwards of thirteen millions and a half. The great use however of the sinking fund *to the minister*, is as an engine of Stock-jobbing, to keep up the price of funds, which national disasters tend to reduce.

THE BUDGET.

So called from the Minister's Bag of papers, necessary to elucidate his calculations on the annual statement (Expose as the French call it) of the national finance. The Budget consists of two parts, viz. THE SUPPLIES; or sums wanted for the year; and THE WAYS AND MEANS, or the sources from whence those sums are to be procured. The supplies consist of the sums wanted for the navy, the army, the ordnance, the payment of dividends or interest on the national debt, the expences of the Civil list, (which include the expences of the Royal family, Judicature, Ambassadors, and Royal pensions) and miscellaneous services. The ways and means are, the consolidated fund, the war taxes, and loans, when necessary. To meet the interest of the new loans, the Budget contains also the new taxes proposed for the purpose, with remarks on the principle of the tax, and calculations on its probable amount from known data. To illustrate this I will give the Budget for 1811, which contains much important fact, and a summary of the Budget of 1812.

IMPERIAL PARLIAMENT.

HOUSE OF COMMONS, MAY 17, 1811.

THE BUDGET.

The House having resolved itself into a committee of ways and means.

The *Chancellor* of the *Exchequer* rose to open the Budget for the present year. He began by observing, that having that morning concluded a contract, subject to the approbation of parliament, for the loan for the service of the present year, on terms which he trusted, under all the circumstances of the case, the committee would consider to be highly advantageous to the public, he should proceed to submit to them the details of that contract. But before he did this he conceived that it would be necessary for him to state, with as much clearness as he possibly could, the various sums which the house had already voted for the supply of the present year, and the ways and means to which in his judgment they ought to resort for the purpose of meeting those sums. The supplies which had been voted were as follow :—

SUPPLIES, 1811.

Navy (exclusive of Ordnance Sea Service) -		*l* 20,276,144
Army (including Barracks and Commissariat) - - - - -	*l* 14,209,422	
Ditto Ireland - - - - - -	3,233,421	
Extraordinaries { England 3,000,000 / Ireland 200,000 }	3,200,000	
Unprovided ditto last year - - -	627,098	
		21,269,941
Ordnance - - - - - - - -		5,012,378
Miscellaneous, including 400,000*l*. Irish permanent Grants - - - - -		2,050,000
Vote of Credit { England - -	3,000,000	
Ireland - - -	200,000	
		3,200,000
Sicily - - - - - - - - -		400,000
Portugal - - - - - - - - -		2,100,000
Joint Charge - -		54,308,453

SEPARATE CHARGES.

Loyalty Loan - - - - -	113,416	
Interest on Exchequer Bills - -	1,600,000	
		1,713,416
Total Supplies - - - -		56,021,869
Irish proportion - - - -		6,569,000
		49,452,869
Irish proportion of 54,308,453*l*. - - -	6,389,000	
Ditto Civil List and other Charges - -	180,000	
	6,569,000	

With respect to the Sicilian subsidy, he had to intreat the indulgence of the committee for a great inattention on his part, namely, in having omitted to lay before parliament the last treaty with Sicily, on which that vote was founded. He had erroneously apprehended that the treaty was already on the table of the house, and it was but three or four days ago that he discovered his mistake. To-morrow, however, or the next day at farthest, he would take care to present it to the house, and he hoped they would accept that apology for his omission hitherto to do so. He would proceed to state the various articles of ways and means, by which he proposed to meet the 49,452,869*l*. of supply to be provided by England.

WAYS AND MEANS, 1811.

Annual Duties			*l* 3,000,000
Surplus Consolidated Fund, 1810			1,353,715
Ditto - - 1811			5,000,000
War Taxes			20,000,000
Lottery			300,000
Exchequer Bills			4,000,000
Vote of Credit			3,000,000
Loan	in 5 per Cent. Stock	4,981,300	12,481,300
	in 3 and 4 per Cents.	7,500,000	
Naval Stores			420,364
			49,595,379

It thus appeared that the total of ways and means exceeded the total of the supply in the sum of 102,510*l.* The committee would however, expect that he would enter into an explanation of the grounds on which he calculated the surplus of the consolidated fund of the present year, at the sum of 5,000,000*l.* To do this, it would be necessary for him to detail the produce at which he estimated the various articles that went to the constitution of that fund.

He took the customs at 5,131,000*l.*; being the average of the produce of the two last years. He had taken a similar average last year, being then 4,485,333*l.*, but in fact the customs had produced 4,987,391*l.*; being about 500,000*l.* beyond the calculation. So with the excise, he proposed to take it on the average of the produce of the two last years, or 17,167,000*l.* Of this article he had also taken a similar average last year, being then 16,880,625*l.*; but the excise had produced 17,399,312*l.* This mode of calculation afforded him a fair scheme of estimate; for although the customs for 1811 fell short by about 200,000*l.* of the customs of 1810, yet the excise for 1810 was surpassed by that of 1811 to a similar amount, the excess of the one balancing the deficiency of the other. The produce of the assessed taxes he had last year estimated at 5,860,000*l.*; they had actually produced 5,781,831*l.* and he would take them for the present year at 5,800,000*l.* The stamp duties he had last year estimated at 5,193,000*l.*; they had actually produced 5,302,743*l.* The great increase in these duties during the last year completely justified him in the statement which he had at that period made, that the whole charge of the year might be defrayed out of their excess. To this statement, however, he had added the observation that it was not probable the same excess would exist

in the succeeding year. He should therefore take the amount of the stamps for the present year only at 5,300,000*l.* The post office revenue was estimated by him last year at 1,194,000*l.*; the actual produce was 1,276,000*l.*, and he proposed to take it for the present year at 1,280,000*l.* He could not pass over this particular article without directing the attention of the committee to the great increase that had taken place during the last two or three years in the receipts at the post-office. In 1809, the post-office had produced 1,083,000*l.*; in 1810, 1,194,000*l.*; and in 1811, 1,276,000*l.*; being an increase on the average of about 90,000*l.* a year, and that not from any additional duties on postage, but simply from the augmented commercial communication of the country. It was clear, therefore, that by taking the amount for the present year only, at 1,280,000*l.* an opportunity was afforded to parliament, if they should think it wise and expedient to avail themselves of it, to relieve Scotland, and other distant parts of the empire, without the danger of any diminution of the estimated revenue. The hawkers and pedlars, and sundry small branches of the revenue, he would take at 106,000*l.*; personal estates and pensions at 156,000*l.*; the land tax at 1,038,000*l.*; the surplus exchequer fees at 54,000*l.*; the tontine at 24,000*l.*; the crown lands, &c. at 66,000*l.*; and the imprest monies at 200,000*l.*; making the total of the estimated receipt of the existing permanent taxes for the present year, 36,322,000*l.*—To this must be added 2,240,000*l.*; being the amount of the war taxes appropriated to the consolidated fund; and the grand total would be 38,562,000*l.*; which being deducted from 38,562,000*l.* the estimated produce of the consolidated fund, would leave a balance of 5,649,000*l.* He would, however, take the surplus only at 5,000,000*l.* and would presently account for the disposal of the balance. With the exception of last year, when the surplus of the consolidated fund was 5,753,715*l.*; of the preceding year, when (from peculiar circumstances) it amounted to 7,019,774*l.*; and of the year 1803, when it was 5,936,651*l.*; that surplus had at no period exceeded, or even reached 5,000,000*l.* This was a highly satisfactory circumstance, in contemplating the state of the finances of the country.

The next item which he thought might require some explanation, was the amount of the estimate for the war taxes for the year ending the 5th April, 1812. This estimate was 20,384,000*l.* The grounds on which he calculated he would state as briefly as possible: The average produce of the custom and excise war duties for the last three years, was 9,296,805*l.* The produce of the last year

was 9,727,213*l.*; but he thought it better to take the average of the three last years. Four hundred thousand pounds remained due from the East India company. These sums, added together, made 9,696,805*l.* The nett produce of the assessment of the property tax for the year ending April 5, 1811, was estimated at 11,800,000*l.* This was 400,000*l.* more than the sum calculated upon as the probable produce, though less than the produce of the preceding year, on account of the great amount of arrears received in that year. The amount of the outstanding arrears of the property tax from 1804 to 1810, was 2,246,644*l.* Of this sum, it was expected that a part would be returned by schedules, and part might not be recoverable; he would suppose one-fourth, or 560,000*l.* Deducting this, the amount, therefore, of outstanding arrears that might be expected to be received, was 1,686,644*l.* Of the estimated produce of the duty for the year ending the 5th of April, 1811 (namely 11,800,000*l.*) 4,864,267*l.* had been received, 6,935,732*l.* therefore remained to be received. This added to the 1,686,644*l.* expected to be received of the arrears of former years, made 8,622,000*l.*; which, with the estimated nett produce of the assessment of the present year, which he would take at the same as the last, namely, 11,800,000*l.* gave 20,422,000*l.* From this, however, must be deducted the sum of 7,524,000*l.* remaining to complete the grant of 1810, leaving a balance of 12,898,000*l.* to be received on account of the property tax. Let this be added to the estimate of the war taxes, 9,696,805*l.* and the result would be 22,594,805*l.* There were war taxes, however, to the amount of 2,240,000*l.* already pledged for the interest of the debt, and which must therefore be deducted, leaving the balance to be received 20,354,805*l.* He would however, take it at 20,000,000*l.*

He now came to the consideration of the loan, and of the ways and means in aid of the revenue to meet the expenses of the year. He had already explained to the committee the state of the loan made in the 5 per cent. stock, and the exchequer bills funded in the present session. These amounted altogether to 12,000,000*l.* by which a capital was created in the 5 per centum stock of 12,444,711*l.* The interest on this capital was 622,235*l.* The sinking fund 124,447*l.* The charges of management 3,733*l.* making a total of 750,416*l.* to be annually provided for, for the loan in the 5 per cent. By the loan of 7,500,000*l.* for which he had that morning contracted, a total charge would be incurred of 465,403*l.* 10*s.* The capital created was 7,500,000*l.* in the three per

cents. reduced; 1,500,000*l.* in the consols.; 1,500,000*l.* in the 4 per cents. For each 100*l.* subscribed, the subscribers were to have half 100*l.* in the 3 per cents. reduced, 20*l.* in the consols. 20*l.* in the 4. per cents and 6*s.* & 11*d.* in the long annuities. By calculation made on the price of stocks on the Saturday before, it appeared that the 100*l.* in the 3 per cents. reduced, which was on that day 64$\frac{1}{8}$th, was equal to 64*l.* 2*s.* 6*d.* That the twenty pound in the consols., which were at 65$\frac{1}{8}$th was equal to 13*l.* 0*s.* 6*d.*, and the 20*l.* 4 per cent. which was at 8 $\frac{1}{8}$th equal to 16*l.* 0*s.* 6*d.* These sums amounted to 93*l.* 3*s.* 6*d.*; and if to this were added the value of the 6*s.* 11*d.* long annuities, namely, 5*l.* 17*s.* 10*d.* the whole would be found to amount to 99*l.* 1*s.* 4*d.* There was a discount, however, of 3 per cent. on the payment of nine months, amounting to 2*l.* 6*s.* 6*d.* and there would, therefore, be a bonus of 1*l.* 1*s.* 10*d.* on every hundred pounds subscribed. He apprehended that a more favourable loan to the public than the present could hardly have been expected; and he had the satisfaction to state to the house that he understood that it was already at a premium of 1*l.* 10*s.* per cent. It had been contracted also with the expectation that the funds were in such a state as to afford every reasonable hope of an improvement, rather than of a diminution of the advantages to the subscribers.

The amount of the interest on this last loan would be 355,937*l.* 10*s.*; of the sinking fund 106,112*l.*; of the charges of management, 3,344*l.* making a total of 465,403*l.* 10*s.*, which, added to the total of the other loan, made the grand total of charge on the two loans, 1,215,819*l.* The rate per centum, including all charges paid by the public, was, on the 7,500,000*l.* loan, 6*l.* 4*s.* 1$\frac{1}{4}$*d.*; on the 12,000,000*l.* funded, 6*l.* 5*s.* 0$\frac{1}{4}$*d.* The rate of interest to the subscribers on the 3 per cent. loan, was 4*l.* 14*s.* 11*d.* per cent.; on the 5 per cent. loan, 5*l.* 3*s.* 8$\frac{1}{4}$*d.* per cent. The difference on the charges being not quite one shilling per cent. and which difference was attributable to the sinking fund. The rate per cent. on the whole debt created, paid by the public, was 6*l.* 4*s.* 8$\frac{1}{2}$*d.* It was a great satisfaction to him to state that so large a portion of the loan of the year had been funded in the 5 per cents. For on a comparison of the 3 per cents. at present with the 3 per cents. of last year; and of the 5 per cents. at present with the 5 per cents. of last year, the committee would be surprised to observe, how little disadvantageous the bargain in the 5 per cents. had been, as compared with that in the three; the 5 per cents. having been much more stationary and not proportionably depressed. When last year 8,500,000*l.*

only was funded in the 5 per cents. instead of 12,000,000*l.* as in the recent instance, the expense created was 6*l.* 4*s.* 7¼*d.* per cent. In the recent instance the expense created was 6*l.* 5*s.* 0¾*d.*, per cent., making a difference of only five-pence halfpenny per cent. between the two charges. The difference in the 3 per cents. in the two years was much greater. Last year the expense was 5*l.* 13*s.* 3*d.* per cent.; this year the expense was 6*l.* 4*s.* 1¼*d.* Last year the interest was 4*l.* 4*s.* 2*d.* per cent.; this year it was 4*l.* 14*s.* 11*d.*, making a difference of above 10*s.* per cent. This was to him a satisfactory reflection, as he had so pertinaciously persisted in procuring the whole of the 12,000,000*l.* to be funded in the five per cents.

Having thus stated that the whole of the charges created by both loans, was 1,215,819*l.* he should next submit to the committee the mode by which he proposed to meet these charges. Before he did this, he must add, that it was his intention to recommend a repeal of the duty on hats, which, ever since he came into office had continued to decrease in amount. When this tax was first levied it produced 60 or 70,000*l.* He did not suppose that fewer hats were worn than formerly; but the fact was, that the produce of the duty last year was only 29,332*l.* It had been gradually diminishing. In 1808 it was 38,000*l.*; in 1809, 33,000*l.*; in 1810, 31,000*l.*; and in 1811, as he had already stated, only 29,332*l.* This was a rapidly decreasing ratio. He was aware, therefore, that in giving up the duty he did not give up much, for it was gradually wearing itself out. It was the cause of great vexation and trouble to the persons carrying on the trade of hat dealers, and particularly to those who dealt on fair terms, over whom the dealer who was disposed to second the fraudulent wishes of his customers, by omitting the stamp, had a very unmerited advantage. The committee was aware that a similar duty on gloves had formerly been abandoned. Before he came to the resolution of proposing the repeal of the duty on hats, he had seriously considered whether it might not be collected in some other manner; but after a good deal of deliberation, he was persuaded that no mode could be adopted which would not be so inconvenient to the trade and to the public, as to render it highly unadvisable. He begged leave to observe, that if in consequence of the repeal of this tax, it should happen that any persons might be led to imagine, that although the duties on gloves and hats were abandoned, it might be expedient to impose others on coats, waistcoats, shoes, or leather breeches, and in consequence to suggest such new duties to government,

it might be a great relief both to those persons who were so kindly ready to furnish the chancellor of the exchequer with the ways and means of the year, and to that individual himself to state that he did not consider it expedient to tax articles of dress. This notice would not appear superfluous to the committee, if they were aware how many letters he was constantly receiving, in which not only every habiliment which could be named, but even the bolts, handles, latches, and other appendages of doors and windows, were recommended by well intentioned persons as fit objects of taxation.

He came now to that part of his duty which was always considered as the most irksome and unpleasant; but on the present occasion he had the highest satisfaction in stating to the committee, that they had already in the course of the session voted taxes to an amount greater than that which was requisite to meet the burdens of the year; and therefore that he should not propose to lay on a single new tax. The fact, indeed, was, that the sum voted was much larger than was wanted. Of these new duties which had been imposed, the principal was that on spirits; the nature of which had already been sufficiently explained, which had received the sanction of the committee, and the bill to impose which was in a state of great forwardness. The probable amount on British spirits from the most accurate estimate that he could obtain would be 700,000*l.* The produce of the duty on British spirits in the year ending 5th April, 1811, was 2,505,448*l.* to which, if the committee added the amount of duty due from the customs in Scotland, and unpaid for the same year, viz. 360,000*l.* it would make 2,865,448*l.* Upon this the additional duty of 19*l.* 4*s.* 7*d.* per cent. would amount to 551,000*l.* The additional duty of 12½ per cent upon the present excise duties on foreign spirits (exclusive of rum) which produced 1,580,000*l.* in the last year, he would state at 200,000*l.* although he did not expect that it would produce so much. There were other taxes, which, although imposed last year, did not begin to operate till the present. Double the amount of the present duty on timber, on the average of the two last years, would be 622,000*l.* An additional 1*d.* per lb. had been voted by the committee on all cotton wool brought from the American states, and other parts (inclusive of British and Portuguese colonies), being, on an average of the last six years, 35,304,000 lbs. and amounting to 174,100*l.* On pearl and pot ashes imported, except from the British colonies, a duty had been imposed of 4*s.* 8*d.* per cwt. On the average of the last six years, the quantity imported annually was 111,000 cwt. making the sum of 25,900*l.* The duty on foreign linen, in pro-

portion to the quarter ending 5th January, 1811, (when the duty first had full effect) would amount to 71,600*l*.—These various sums, added together, would give 1,617,600*l*. The committee would, however, be aware that these duties were of course subject to such diminution as might be occasioned by the discouragement of the articles on which they were imposed, as they were intended to produce. This diminution would probably not be very considerable for some period; but he had no doubt, and, indeed, sincerely trusted, that they would ultimately be very much diminished, as in proportion to that diminution would the encouragement to English articles increase. These duties he proposed to go in accumulation of the war taxes, and he conceived, that in giving 866,600*l*. to the war taxes he should not be unjustifiable in taking from them 465,403*l*. which sum, added to the produce of the two duties on spirits, viz. 751,000*l*. would give him the 1,215,819*l*. which he required. Then, however, there would be a balance of 300,000*l*. of the war taxes unappropriated and applicable to the ways and means of the year, and also 600,000*l*. of surplus of the consolidated fund. The committee must recollect, that these new taxes had been voted at an advanced period of the year, one quarter having nearly elapsed, and a consequent deficiency of one-fourth ensuing; it would therefore be expedient to meet this deficiency out of the surplus of the consolidated fund, and 250,000*l*. must be deducted from the 600,000*l*. on that account.

He had now to submit to the committee a very important consideration, to which he should call their most serious attention. As soon as the present subject was finished, his right honourable friend (Mr. Foster) would proceed to lay before them the situation of the finances of Ireland. His right honourable friend would have to state that he had borrowed for the service of Ireland 2,500,000*l*. in that country, and that he had borrowed 4,500,000*l*. in England for the same service. To meet the expenses of the loan raised in Ireland, his right honourable friend was ready to propose the necessary taxes; but he (the chancellor of the exchequer) had no hesitation in saying that he trusted the committee would agree with him in thinking that, in the present distressed state of the Irish finances, it would not be wise or expedient to call on his right honourable friend to lay taxes on that country for the purpose of meeting the expenses of the loan of 4,500,000*l*. raised in England. It was therefore his intention to propose to the English members and to the Irish members of the house of commons, that the expenses of that part of the loan raised for the service of Ireland

should be charged on the consolidated fund of England (as a loan to Ireland), in order to procure the public creditor a permanent security, and for at least a twelvemonth, while an inquiry was making into the finances of that country to bear the intesest of the money so raised. He trusted that the committee would be of opinion, whatever might be the issue of that inquiry, that it would be advisable to come forward in the way which he recommended, and out of the comparative affluence of the English finances, to afford aid to Ireland in that, the hour of its particular embarrassment. With a view of furnishing the committee with the means by which this great good could be effected to Ireland, without any inconvenience to this country, he had forborne to take more than 5,000,000*l.* from the surplus of the consolidated fund, leaving a sufficient sum to meet the proposed cha ge. Though this was a novel proposition, he was persuaded it would be received without grudging, or any indisposition on the part of the committee, to afford to Ireland that assistance which he had shown could be afforded to her, without any material inconvenience to Great Britain. He repeated that the inconvenience would be immaterial; for, what was the nature of the additional taxes, by which the surplus of the consolidated fund would be so much increased as to enable the committee to do that which he recommended? The duty on British spirits had been founded on a principle which had over and over again been recognised by the committee as just. After the experience of last year, namely, having found that spirits had continued to be sold at the increased price to which they were raised when distilled from sugar, there were no reasons to suppose there would be any diminution in the consumption of the article, from the very small advance on the price which the present duty could be expected to occasion. With respect to the other duties, they were all recommended to the committee, on views very different from those connected with finance. They were proposed expressly for the purposes of endeavouring to procure for British shipping those imports, which the war in which the country was engaged, necessarily limited (and which were now enjoyed by foreigners); and of encouraging the exertions of British manufactures, and the consumption of British colonial produce. Policy would have dictated these measures without any reference whatever to their beneficial tendency with respect to finance. He was therefore justified in saying that Ireland might be assisted without prejudice to Great Britain, and he trusted that the assistance would be received in Ireland as it would be given by this country; namely, as affording a

mark of our disposition to lend every possible aid to Ireland under the embarrassing circumstances in which she was placed, and as tending to inforce the necessity and policy of either country stepping to the support of the other, when the one was able to give, and the other so situated as to require assistance.

He believed that he had now stated, as fully and distinctly as he had it in his power to do, all the considerations immediately connected with the subject before the committee. He trusted that he had not omitted any necessary explanation; but before he sat down, he wished to mention a few circumstances, in order to show the general increase of the revenues, and the affluence of the country. For this purpose be begged the attention of the committee to the increasing produce of the customs and excise, during the last five years. In the year ending the 5th of April 1807, the produce of the customs was 9,612,000*l.*; in 1808, 9,123,612*l.*; in 1809, 8,508,258*l.*; in 1810, 10,536,775*l.*, and in 1811, 10,523,169*l.* being an increase of near a million since the year 1807. The produce of the excise in the year ending 5th April, 1807, was 23,740,518*l.*; in 1811, 24,646,022*l.* In the intermediate years the advance was gradual, with the exception of 1809, in which year there was a considerable falling off, the produce being only 22,837,856*l.* In the two succeeding years, however, this depression was completely recovered. An inquiry into other articles of general consumption, would contribute to show the increasing opulence of the nation. The produce of the duties on cotton wool imported into the country in 1807, was 513,526*l.*; the produce in the year 1811, was 1,034,142*l.* The duties on deals and fir-timber imported in 1807 were 566,247*l.* In 1811 they amounted to 642,104*l.* The excise duties on tea in 1807 were 2,844,395*l.* In 1811 they amounted to 3,236,027*l.* This last was a more extraordinary increase, as the article was under most heavy taxation, and as the increase took place after the operation, from which so much mischief was anticipated, of the reduced duty on coffee. All this could be accounted for only by the general augmentation of wealth in the country. Of this increasing wealth a most striking instance was afforded in the consumption of wine. In 1785 the quantity of wine consumed was 14,550 tons; in 1786, 15,087 tons; in 1787, 14,780 tons; making the average of the three years an annual consumption of 14,800 tons. At that period the average price of port wine was 70*l.* 11*s.* 10*d.* per pipe. In 1807, the quantity of wine consumed was 24,090 tons; in 1808, 24,757 tons; in 1809, 22,331 tons; the average of these three years being an annual consumption of 23,726 tons

At the former period the duty was 30*l.* per ton; at the latter 95*l.* The average price at the latter period 192*l.* 14*s.* per pipe: so that under both the increase of duty and the increase of price the consumption had increased. He could hardly adduce a more striking instance of general prosperity. The average consumption of tallow, for the three years ending in 1787, was 210,174 cwt. The average for the three years, ending in 1809, was 347,870 cwt. The price at the former period was 2*l.* 8*s.* 8*d.* per cwt.; at the latter period, 4*l.* 11*s.* being one third more. Nor did this increase in the consumption of tallow arise from any decrease in the consumption of oil. The average consumption of oil for the three years, ending in 1787, was 9,730 tons; the average consumption for the three years, ending in 1809, was 19,126 tons. The price at the former period was 19*l.* 18*s.* 9*d.* per ton; at the latter period 32*l.* 8*s.* The average quantity of tobacco annually imported for the three years, ending in 1787, was 6,553,000*l.* The annual average for the three years ending in 1809, was 12,491,000*l.* The price at the former period was 8½*d.* a pound; at the latter 1*s.* 7¾*d.* He was aware that these details were very tedious, but he had the consolation of knowing that they were at the same time very satisfactory, as they afforded the most convincing evidence of the gradual but great increase of the riches of the country.

On the 17th July, Mr. Vansittart, the *pro tempore* Chancellor of the Exchequer, brought forward the budget of the year 1812, and it presented the following series of items:

The expences of the navy - -	*l* 19,702,399
The army - - - -	17,756,160
Army extraordinaries - - -	5,200,000
The ordnance - - - -	5,279,897
Extraordinary services - - -	10,250,000
Sundry charges - - - -	4,187,892
Total expences of warlike establishments	62,376,348
The charges of the interest of the debt and the civil list are	36,356,000
Total for the year	*l* 98,732,348

The means of raising this enormous *minimum*, for, after all, it is but the *minimum* of the true amount, are taxes and inquisitions on every act of life, and on all articles either of necessity or luxury.

The consolidated fund, or permanent taxes, producing	39,750,000
The War Taxes - - -	20,500,000
The Loan - - - -	20,000,000
The New Taxes - - -	1,900,000

The balance is made up by 3 millions of Annual Duties, by subscription to Exchequer Bills 7 millions, by a Vote of Credit 3 millions, and by smaller items, producing, by the figures on the minister's paper, not more than 40,000*l.* excess, supposing the taxes to produce as calculated. The government have, however, for some time past adopted a means of supplying pressing necessities, by issuing Exchequer Bills, and the present amount of those in circulation is unknown.

The Loan. Bonus. Premium. Scrip. Omnium. Discount.

When a sum of money is wanted for the service of the current year, it is usually borrowed and funded, that is made a part of one of the regular funds; to which, the taxes laid for the interest are also appropriated. The minister gives notice that he shall want so much money, and the monied men, send in, written proposals of the rate at which they will advance the loan, or a part of it. The lowest rate is of course usually preferred.

The minister however does not burthen any one fund with the whole sum required to be borrowed, for this would occasion a difficulty of sale and transfer, by overloading the market with one stock; but divides it among several stocks. Thus, suppose the subscribers are to have 5 per cent. interest for their money: then if they have 100*l.* in the 3 per cent. consols, this will give them but 3 per cent. out of the 5, and is therefore only 60*l.* The minister and they then agree, that they shall also have a certain sum in some of the other stocks, redeemable annuities for instance, which are valued at the current market price. It is evident that this method greatly encreases the nominal amount of the debt. Then the minister sells them a lottery ticket at its original price, and sometimes advantages were also given in the period of payment of the instalment, which gives an advantage of interest, and discount. Whatever all these items make beyond the 100*l.* subscribed to be paid, is Bonus. The advance which the subscribers can actually sell their bargain for in the market is Premium. When they are allowed to pay by instalments, instead of the whole sum at once, and no deduction is made, then they gain Discount.

SCRIP, is the subscription to the loan or any item of it, brought into market for sale.

OMNIUM. Is the aggregate bargain made with the minister, consisting of all the items belonging to it, such as consols, redeemable annuities, lottery ticket, discount, &c. brought into market for sale.

UNFUNDED DEBT.

Certain great officers of government are allowed in the intervals between the parliaments, to borrow for the national wants such sums as may be necessary by issuing exchequer bills, navy bills, and ordnance debentures. During lord North's administration, these used to be issued payable at 12 and even 18 months; of late years, they are payable at much shorter dates, as 90 days. These are transferable in the stock market. Every now and then, when the quantity issued and thrown into circulation affects the price of stocks, the minister is compelled to fund them; that is, to annex the amount to some one or more regular aggregate or fund; and appropriate taxes to pay the interest. Thus the national expenditure, and national debt, can never be accurately known to the public, until the items of unfunded debt issued within the year, are known and funded.

FINANCE OF IRELAND.

Annual permanent revenue in Irish currency.

1808	Gross produce	5,531,669	Nett produce	4,417,990
09		5,549,191		4,571,406
10		5,416,715		4,280,603
11		5,130,610		3,614,135

		Customs.		*Excise.*	
1808	G. pro.	1,836,843	G. pro.	1,773,760	This comprehends the customs on spirits, sugar, tea, tobacco, and wine; and the excise on malt, spirits, and tobacco.
09		1,991,691		1,538,761	
10		2,364,241		951,851	
11		1,606,752		1,345,403	

The Debt of England, and of Ireland, funded and unfunded, to the first January, 1813, is already given in pages 250, 251, 252.

A TABLE

Shewing the progressive increase of the taxation, expenditure and national debt of Great Britain, from the accession of queen Anne, 1702, to the 5th of January, 1810. Also the amount of debt redeemed from the first operation of the redemption act, 1786, to the first of February, 1810. Together with the amount of all the loans from 1776 to 1810.

		Taxation.	*Expendit.*	*Debt.*
1702	Death of William III. accession of Anne	*l* 4,212,353	*l* 5,610,987	*l* 16,394,702
1714	Death of Anne, accession of George I.	6,762,643	6,633,581	54,145,363
1727	Death of Geo. I. accession of Geo. II.	6,522,540	5,441,257	52,092,235
1760	Death of Geo. II. accession of Geo. III.	8,744,682	24,456,940	146,682,814
1784	After the close of the American war and at the commencement of Mr. Pitt's administration,	13,300,921	21,657,609	257,213,043
1802	After the close of the last war commonly called the French revolution war,	36,728,971	61,278,018	579,931,447
1810	5th January,	70,240,226	82,027,283	811,898,081

The national funded debt 761,117,455*l.* 18*s.* 0¾*d.* *Unfunded debt*, 50,780,625*l.* 14*s.* 3*d.* *Redeemed debt*, 163,679,089*l.* January 5, 1810.

The funding system commenced 1696, eighth year of William III. The first monies raised were laid as duties on salt and stamps, to the amount of two millions. At the death of William III. whose reign was one continued scene of warfare, the debt amounted to 16,394,702*l.* At the death of Anne, 1714, whose reign, the last year excepted, was war, the debt had increased more than three fold, being 54,145,363*l.* At the death of George I. 1727, the debt had decreased more than two millions, being at that period 52,092,235. At the death of George II. 1760, a period of thirty three years from the death of George I. in which two wars had taken place, the debt had nearly doubled, being 146,682,814*l.* In 1784, after the close of the American war, and at the commencement of Mr. Pitt's first administration, a period of twenty four years from the accession of George III. the debt almost doubled itself, being 257,213,043*l.* At the close of the year 1802, the termination of the French revolution war, a period of eighteen years, the debt had more than doubled itself by sixty-five millions, being 579,931,447*l.* From the close of the year 1802, to the beginning of the year 1810, a period of seven years only, the debt had increased two hundred and thirty-two millions, the whole amount of the national debt, funded and unfunded, on the 5th January, 1810, being 811,898,081*l.*

Amount of Loans from the commencement of the American War to the present time.

American War.			French Revolution War.			Present War.		
Date.		*Interest.*	*Date.*		*Interest.*	*Date.*		*Interest.*
1776	£2,000,000	£3 9 8	1793	£ 4,500,000	£4 3 4	1803	£12,000,000	£5 2 0
77	5,000,000	4 5 2	94	11,000,000	4 10 9	4	14,500,000	9 9 2
78	6,000,000	4 18 7	95	18,000,000	4 15 8	5	22,500,000	5 3 2
79	7,000,000	5 18 10	96	18,000,000	4 14 9	6	18,000,000	4 19 7
80	12,000,000	5 16 8	96	7,500,000	4 12 2	7	12,000,000	4 14 7
81	12,000,000	5 11 1	97	18,000,000	5 14 1	8	8,000,000	4 14 6
82	13,500,000	5 18 1	97	14,500,000	6 6 10	9	11,000,000	4 12 0
83	12,000,000	4 13 9	98	17,000,000	6 4 9	10	13,500,000	4 4 3
84	6,000,000	5 6 11	99	3,000,000	5 12 5			
			99	15,500,000	5 5 0			
			1800	20,500,000	4 14 2			
			1	28,000,000	5 5 5			
Total, £75,500,000			*Total,* £175,500,000			*Total,* £111,500,000		

A General View of the National Income and State of Society, in England and Wales, according to Mr. Greg. King's estimate, Anno 1688.

Number of Heads of Families.	Ranks, Degrees, Titles and Descriptions.	Persons in each family.	Aggregate number of persons in the Family of each Rank.	Yearly Income.	Aggragate income of each rank.
				£	£ *sterling*
160	Temporal peers - -	40	6,400	3,200	512,000
26	Spiritual lords - -	20	520	1,300	33,800
800	Baronets - - - - -	16	12,800	880	704,000
600	Knights - - - - -	13	7,800	650	390,000
3,000	Esquires - - - - -	10	30,000	450	1,200,000
12,000	Gentlemen - - - - -	8	96,000	280	2,380,000
5,000	Persons in greater offices and places	8	40,000	240	1,200,000
5,000	Persons in lesser ditto	6	30,000	120	600,000
2,000	Eminent merchts. by sea	8	16,000	400	800,000
8,000	Lesser merchants by sea	6	48,000	198	1,600,000
10,000	Persons of the law -	7	70,000	154	1,540,000
2,000	Eminent clergymen	6	12,000	72	144,000
8,000	Lesser clergymen	5	40,000	50	400,000
40,000	Substantial Freeholders	7	280,000	91	3,640,000
120,000	Lesser freeholders	5½	660,000	55	6,600,000
150,000	Farmers - - - -	5	750,000	42½	6,375,000
15,000	Persons of the liberal arts and sciences	5	75,000	60	300,000
50,000	Shopkeep. & tradesmen	4½	225,000	45	2,250,000
60,000	Artisans and handicrafts	4	240,000	38	2,280,000
5,000	Naval officers - - -	4	20,000	80	400,000
4,000	Military officers - -	4	16,000	60	240,000
35,000	Common soldiers - -	2	70,000	14	490,000
50,000	Common seamen - -	3	150,000	20	1,000,000
364,000	Labouring people -	3½	1,275,000	15	5,460,000
400,000	Cottagers and paupers	3¼	1,300,000	6½	2,000,000
	Vagrants, beggars, gipsies, thieves, and prostitutes		30,000		60,000
1,349,586	Net Totals.	4¼	5,500,520	£	43,491,800

SIMILAR VIEW FOR 1803, BY P. COLQUHOUN, ESQ. L. L. D.

Description of Classes.	Single Persons.	Families.	Aggreg. No. of Persons.	Aggregate Incomes.
1. The Sovereign, for himself, his Queen, and resident family - - - - - -		1	50	l 200,000
2. Peers, country gentlemen, and freeholders of lands and houses, &c. mines, minerals, funds and public incomes - - - - - - - - - - - - -		167,177	898,775	32,241,000
3. Persons having colonial and East India property, funds, and jointures, &c. including foreign incomes - - - - - - - - - - - - -		20,000	160,000	14,000,000
4. Merchants and bankers, deriving income from trade, funds, lands, &c. - -		15,000	111,000	15,600,000
5. Ship-owners, deriving income from freights and other property - - - -		5,000	25,000	2,500,000
6. Manufacturers of all descriptions, including ships, houses, works, &c. &c.		55,300	301,800	24,960,000
7. Inland traders & shopkeepers of all descriptions, trad. on capitals, including publicans		125,000	625,500	16,575,000
8. Agriculturalists or farmers, graziers, and dealers in cattle, &c. - - - -		160,000	960,000	19,200,000
9. Established clergy, and dissenters from the church duly ordained - - - -		13,526	68,890	2,104,000
10. Liberal professions—*law*, *physic*, *literary*, and the *fine arts*. - - - - -		27,300	136,500	8,088,000
11. Persons employed in the education of youth, including universities - - - -		20,500	122,000	3,300,000
12. Persons employed in theatrical and musical exhibitions - - - - - -		500	2,000	400,000
13. Civil and military labourers for the state, and in its defence, &c. - - - -	387,079	110,675	466,500	17,494,575
14. Labourers in agriculture, manufactures, commerce, navigation, and fisheries, &c. exclusive of menial servants - - - - - - - - - - - - -		1,183 004	5,226,646	53,511,720
15. Hawkers and pedlars, with and without licenses - - - - - - - -	2,500	800	4,000	100,000
16. Persons employing capitals in asylums for lunatics and deranged persons -		40	400	20,000
17. Lunatics supported in asylums - - - - - - - - - - - -	2,500		2,500	75,000
18. Persons confined in prisons for debt - - - - - - - - - - -	3,510	2,000	10,000	87,750
19. Vagrants, gipsies, common prostitutes, and criminal offenders in prisons and at large	222,000		222,000	2,220,000
20. Paupers included among the class of labourers who only earn part of their subsistence, the deficiency made up by parishes to the amount of - - - - - -	1,040,716			4,267,000
21. Persons, included in all the above descriptions of families, who have money in the funds or otherwise, either as trustees for orphans, minors, and charitable institutions, or on their own account - - - - - - - - - - - - -				5,055,955
		1,905,823	9,343,561	222,000,000

(1 Niles's Register, 22.)

General results—Collected from many authorities.

POPULATION.

In G. Britain, including the army, navy, convicts and seamen in registered vessels, by the census of 1801, there were, persons - - - - - - -	10,979,089
In Scotland - - - - - - - - -	1,654,000
In Wales - - - - - - - - - -	541,546
There were in G. B. under 15 years of age, persons	3,659,796
Males between 15 and 60 years of age - -	2,744,847
Persons above 60 years of age - - - -	819,357
Volunteers in G. Britain and Ireland—(1805) -	700,000
Persons employed in agriculture (England, 1805)	1,524,227
in trade and manufactures do.	1,789,539
In the army and navy (1801) men - - - - -	*469,188
Persons employed in agriculture in Wales (1805)	189,062
Ditto in trade and manufactures - -	53,822
Paupers—England and Wales: permanent 651,349; ——— occasional relief, 305,899; ——— in the work houses 83,468	1,040,716
Mendicants - - - - - - - - -	50,000
Vagrants, gypsies, &c. - - - - - - -	20,000
Idle and immoral - - - - - - - -	10,000
Prostitutes - - - - - - - - -	100,000
Vagabonds and criminals - - - - - - -	100,000
In the friendly societies of G. B. in 1803, there were	674,226
The population of Ireland, (1801) was, persons -	5,496,944

Of 63 marriages only three are found without offspring.
Married couples are, to the whole population, as 2 to 11.
Births are, to the population, as 1 to 28.
Menial servants, ditto, as 1 to 11 nearly.

Inhabited houses in England are - - -	1,575,923
Uninhabited do. do. - - - - - -	56,300
Inhabited houses in Ireland - - - - - -	687,618
Uninhabited do. - - - - - - - - -	24,130

There are 122 cities and towns in Great Britain with upwards of 5,000 inhabitants each.

EXTENT, SURFACE, &c.

The sea coast of Great Britain is in miles about - - 3,800

* The number employed in 1811 is probably about 600,000.

England and Wales contain, square miles	- -	49,450
Scotland	ditto - - -	27,749
Ireland	ditto - - -	27,457
In England there are, acres	- - - -	34,271,000
——— acres of uncultivated land	- - -	12,151,471
In Scotland, there are, acres	- - - -	19,556,540
In Wales	ditto - - - -	5,370,000
In the whole island	ditto - - - -	50,409,443
In Ireland there are (Irish acres, 7 yards to the rood)		12,001,200

There are 12 acres to every person in Scotland—nearly 10 acres to every person in Wales, hardly 4 acres to every one in England, and about the same space, (in English acres) for each person in Ireland.

Money, Stocks, &c.

Specie circulating unknown; but difficult to be had, and bearing a high premium.

Whole nominal public debt, 1811*	*l* 811,893,082	$3604,805,284
——— Sinking fund	196,546,775	872,678,781
Nominal public debt of Ireland (about)	75,000,000	333,000,000
Bank of England notes in circulation, Jan. 12, 1810—		
Of *l* 5 and upwards	*l* 14,668,640	
Bank post bills	884,120	
Under *l* 5	5,854,170	$93,936,969
Bank of Ireland notes (Oct. 1, 1803)		
Of *l* 5 and upwards 1,769,950 9 11		$12,351,364
Under *l* 5 1,011,891 7 4		
Notes of private bankers in *England* estimated in Oct. 1810	*l* 84,000,000	472,860,000
Notes of private bankers in *Ireland* (Oct. 1810)	12,000,000	53,280,000
The whole public circulating *paper* medium in Great Britain and Ireland, excluding the notes of private bankers in Scotland, of whose business we have no estimate, therefore amount to the *inconceivable* sum of - - - - - - - -		$4570,333,417
The rents of lands in Great Britain are	*l* 27,000,000	119,880,000

* The debt for 1812 and 1813, I have already given. T. C.

The *whole* annual income of the people (1805) including revenues, resources and earnings of individuals, *of every description.*	*l* 243,000,000	$ 1078,920,000
Valuation of all the real and personal property in *Great Britain*	3,000,000,000	$ 13,320,000,000

Of "Bank Dollars," as they are called, there were

stamped and issued in	1797	2,325,099
Ditto	1804	1,419,484
Ditto	1809—10	1,073,051

By Charles II. gold and silver was coined to the value of		*l* 7,524,105
By James II.		2,737,637
Anne		2,691,625
George I.		8,725,921
George II.	gold 11,662,216 silver 301,360	11,966,576
George III. before December 31, 1780	gold 30,457,457 silver 7,480	
From 1780 to 1802,	gold 33,310,832 silver 56,473	86,277,500
1802 to March 25, 1810	gold 22,445,258	
Whole coinage since 'the restoration,' A. D. 1660—equal to		$ 532,459,730

Revenue, Taxes, &c.

The nett revenue, payable into the exchequer, for the year 1810, was	*l* 70,235,792	$ 311,344,695
The loans for the same year produced in *addition*		$ 59,922,777
Poor rates in England, 1810	*l* 6,500,000	$ 28,860,000
Amount of tythes in do.	*l* 5,000,000	22,220,000
The *whole receipt* of the *clergy* in England may be estimated at		44,444,444
There are 2 archbishops and 24 bishops in England, whose *regular* annual receipt is at least	*l* 120,000	532,800

In England and Wales there are nearly 600 *livings* as they are called, under 50*l*. *per annum*—of which 1071 do not exceed 10*l*., and 1467, 20*l*.

The proportion of the land tax of Scotland, compared with that of England; is as 1 to 14—

the landed property is estimated as 1 to 16—and the wealth as 1 to 20.

The nett revenue for Ireland, payable into the exchequer, for the year ending Jan. 5, 1809—was	*l* 6,174,561	$ 27,415,050
The loans for the same year produced an *addition* of		24,019,292

EXPENDITURE.

Gross amount of expenditure for Great Britain, including payments for interest of the national debt, &c. 1810	*l* 83,099,186	$ 368,959,385
Some of the chief items of which were—		
For the support of the Navy	24,466,998	53,133,461
Army	17,019,729	78,131,594
Ordnance	4,732,276	21,001,347
The *civil list* - - - -	958,000	4,253,520
The *princes* and *princesses* - -	278,281	1,235,567
On account of interest of the national debt, charge of *management, reduction*, &c.	32,000,000	142,080,000
The public expenditure of *Ireland* for the year ending Jan. 5, 1809, was	9,536,205	42,341,149
Some of the chief items of which were—		
For interest, charge of management and reduction of the public debt	3,359,077	14,914,301
Army - - - - -	3,410,694	15,143,481
Ordnance - - -	519,184	2,305,176
Miscellaneous services - -	512,197	2,274,154

COMMERCE AND MANUFACTURES.

Shipping belonging to Great Britain and her colonies, Ireland not included, (1805) *tons*,	2,226,000
Ships built in Great Britain, 1810, *registered tons*	122,683
Whole registered tons in the British king's dominions, 1810	2,549,683
Were navigated by - - - - - *men*	164,030

British manufactures exported, 1809, (*real value**)	*l* 44,702,637	$ 198,513,008
Total exports, same year, *ditto*	68,972,743	306,239,089
Imports, same year, *ditto*	46,138,179	204,809,103
Amount of imports and exports *do.*	115,180,912	511,403,649
Ireland——real value of exports, Irish growth, produce or manufacture, 1809	12,577,517	56,954,175
Ditto—imports (about) - -	13,500,000	60,940,000
British manufactures for *home consumption*	92,607,364	408,982,816
Whole value of British manufactures† on an average for 5 years	137,301,605	609,659,086
Real value of Woolen goods *exported*, 1809	13,980,263	61,961,367
—— of imports from the West Indies	17,000,000	75,480,000

MISCELLANEOUS.

Members of the House of Commons—
For England, 489,—Scotland, 45—Wales, 24—Ireland, 100—total 658

* There is an *official* value and a *real* value. As for instance, the *official* value of goods imported in 1809 is stated at only 27,509,400*l.* though the *real* value is placed at 46,138,479*l.* as above stated, on the authority of a late *ministerial* writer. So as to the exports for the same year—the *official* value was but 38,327,495*l.* and the *real* value is estimated at 68,972,437*l.* By these distinctions, politicians both sides of the question, sometimes, even when telling the *truth*, lead us into gross errors, by giving the *official* value for one part of their statement and the *real* for the other, or *vice versa*, as suits their purpose. From the nature and design of the work from which this part of our table is quoted, we have full reason to believe the *real* value (as it is called) is placed *as high* as it would bear; but have no document whereby to test its correctness.

† This is presumed, for sundry good reasons, to include all the productions of the *mechanic* arts necessary to the ordinary wants of the people, as well as what is generally understood by the word *manufactures*.

The number of the house of lords are indefinite; the king can make as many as he pleases.	
In 1793 it was estimated that twenty-four millions of bushels of grain, valued at three millions pounds, were made into drinks in G. Britain.—☞The consumption of grain for this purpose has greatly declined since that period, sugar being substituted for distillation.	
There were imported into England for the 3 years, 1802, 1803, 1804, lbs. of wool	18,467,718
Of which there came directly from Spain, lbs.	16,986,644
Annual average from 1804 to 1808 - -	6,250,000
The value of the wool imported in these years was	£5,560,000
Woolen cloth was never dyed and dressed in England until the year 1667.	
The annual consumption of silk in the various manufactures, which is chiefly imported from Italy and India, has been estimated at 11,460 bales—of 140lbs. each—lbs.	1,604,400
☞ The stock has latterly been short—the above estimate is for the year 1807.	
The annual consumption of cotton is about lbs. *per ann.*	65,000,000

FROM FORDYCE'S COMMITATUS ANGLORUM.

Stastistics for 1801.

There are in Great Britain including the army, navy &c.—

Inhabitants - - - - - -	10,979,039
Of which under 15 - - - - - -	3,559,796
From 15 to 60 - - - - - - - -	6,744,847
Volunteers of United Kingdom - - - -	700,000
Militia of Great Britain - - - - - - -	70,386
Persons employed in England in agriculture - -	1,524,227
——in trade and manufactures - - - -	1,789,532
In England there are acres - - - - -	34,271,000
—In Scotland - - - - - - - -	19,565,540
—Wales - - - - - - - - -	5,370,000

There are in England scarcely 4 acres to each person, 12 acres to each person in Scotland, and nearly 10 to every person in Wales, about 5 acres to each person in Great Britain, three acres well cultivated are supposed sufficient for each person.

The inhabitants of Ireland are - - - -	5,496,944
There dies in Great Britain every year - - -	332,708
Every month - - - - - - - -	25,592
——week - - - - - - - - -	6,398
——day - - - - - - -	914
——hour - - - - - - -	40
——three minutes - - - - - -	2

Number of inhabitants in the Thirteen largest Cities and Towns of Great Britain, according to a Census taken in 1801.

London, including Westminster and Southwark -	864,825
Manchester - - - - - -	84,020
Edinburgh, including Leith - - - -	82,560
Liverpool - - - - - -	77,653
Glasgow - - - - - -	77,385
Birmingham - - - - - -	73,670
Bristol - - - - - - -	68,645
Leeds - - - - - - -	53,262
Plymouth - - - - - -	44,194
Sheffield - - - - - -	32,166
Paisley - - - - - -	31,179
Hull - - - - - - -	29,156
Dundee - - - - - - - - -	26,084

Summary of the Population as lately taken by Government, and presented to both Houses of Parliament.

Population 1801.

	Males.	*Females.*	*Total.*
England - - -	3,897,935	1,343,499	8,331,434
Wales - - -	257,178	234,368	541,546
Scotland - -	734,581	864,487	1,599,068
Army, Navy, &c. -	470,598	- - - -	470,598
Totals	5,450,292	5,492,354	10,942,646

Population 1811.

	Males.	*Females.*	*Total.*
England - - -	4,535,257	4,944,143	9,499,400
Wales - - -	289,414	317,966	607,380
Scotland - - -	825,377	979,487	1,804,864
Army, Navy, &c. - -	640,500	- - - -	640,500
Totals	6,310,548	6,241,596	12,552,144

	Increase.
England - - -	1,167,966
Wales - - - -	65,834
Scotland - - - -	208,180
Army, Navy, &c. - -	169,902
Total	1,611,882

DISTILLERIES.

The following is the amount of duties paid by the distillery in Great Britain for the last seven years, from the 5th January 1804 to 5th January 1811:—

5th	January	1804 to 5th	January	1805	2,322,309*l*	7*s*	8¾*d*
5th	ditto	5 to 5th	ditto	6	2,305,884	17	1¼
5th	ditto	6 to 5th	ditto	7	2,313,869	10	7
5th	ditto	7 to 5th	ditto	8	2,706,563	12	2½
5th	ditto	8 to 5th	ditto	9	2,757,804	14	9
5th	ditto	9 to 5th	ditto	10	2,056,079	16	7½
5th	ditto	10 to 5th	ditto	11	2,427,916	3	5¼

It will be observed, that the returns of the last two years, when the distillation from grain was prohibited, is considerably below that of any of the preceding years. But, besides this diminution of revenue, when sugar is employed, it ought also to be mentioned, in any comparative view which may be taken of the advantages and disadvantages attending distillation from these commodities, that, during these two years, 1811, 1812, there is, besides, a loss sustained of the entire duty paid on the malt in the other years, amounting to *l* 250,000 more annually. The total amount, therefore, of the difference between the last two years of the above returns, when sugar was used, and the two years preceding, when malt was employed, is not less than 1,480,373*l*. 6*s*. 10½*d*. nearly *one million and a half sterling*. Whenever the arguments in favour of each of these two commodities appear to be nearly balanced, we have no hesitation in saying that the consideration of such a loss to the revenue, ought to turn the scale in favour of grain. *Com. Mag.*

Circulation of Bank Notes.—The following is an account of the amount of the Bank of England Notes in circulation on the 25th of each of the first six months of 1811; distinguishing the amount of those above and below 5*l*.

1811.	Bank Notes of 5*l.* and upwards, including Bank Post Bills.	Bank Notes under 5*l.*
January 25th	16,443,940	7,305,830
February 25th	15,568,370	7,187,200
March 25th	16,167,750	7,176,280
April 25th	16,662,540	7,331,920
May 25th	15,959,170	7,290,640
June 25th	16,140,360	7,297,200

London Brewery of Strong Beer.—The following is the statement of the quantity of strong beer brewed by the twelve principal houses in London, between the 5th July, 1810, and the 5th July, 1811:

	Barrels.		Barrels.
Barclay	264,105	Goodwyn	85,181
Meux	220,094	Coombe	81,761
Hanbury	142,179	Brown and Parry	72,367
Whitbread	122,316	Elliott	58,042
Calvert	105,887	Taylor	46,222
H. Meux	103,152	Clowes	36,872

Statement of the Emoluments of the Lord Chancellor, &c.—It appears from the Report of the Committee of the House of Commons upon the emoluments of the Lord Chancellor, &c. that his *acknowledged* income in his jurisdiction as Chancellor for the year ending the 5th of April, 1811, was 15,532*l.* 13*s.*; and as Speaker of the House of Lords, for the last year, 6,844*l.* 15*s.* making together an annual sum of 22,377*l.* 8*s.* being an increase of about 7000*l.* a-year within the last ten years. The produce as Chancellor was, last year, almost 3,500*l.* greater than the preceding year, owing to the extraordinary increase of bankruptcies!!

Statement of Balances of Money and Securities of the Suitors in the Court of Chancery, in the different periods undermentioned; as represented by the Lord Chancellor to the Committee of the House of Lords.

YEARS.	*l.*	*s.*	*d.*
1730	1,007,298	14	7
1740	1,295,251	16	3
1750	1,065,160	18	4
1760	3,093,740	0	3
1770	5,153,901	1	3
1780	7,120,537	12	2
1790	10,948,270	7	0
1800	17,565,912	2	8
1810	25,162,430	13	2

Suitors money deposited in the high court of admiralty and court of appeals for prizes on the 1st. January 1810, 461,764*l.* In 1811, 400,750*l.* In 1812, 262,460*l.*

List of *Theatres* in London 1812. Covent Garden will hold 3000 persons. Drury Lane 2800. Opera house 3500. Pantheon 3000. Haymarket or little theatre 1800. Lyceum 2000. Surrey Theatre 2500. Astley's Olympic Theatre 1500. Astley's Amphitheatre 2500. Sadler's Wells 2200. Sans Pareil 1500. Regency theatre 1600. Royalty Theatre 1600. In all about 30,000 Spectators. The population to support these, amounts in round numbers to one million of Souls.

The following is a return of the number of *persons charged with criminal offences*, who were committed to the different gaols in England and Wales for trial, at the assizes and sessions held for the several counties and places therein, in the year 1811; and the total for seven years, from 1805 to 1811.

	1811.	Total in 7 years.
Committed for trial—Males	3,859	24,246
Females	1,478	2,699
Total	5,337	33,945
Convicted	3,165	20,147
Sentences, viz. Death	*494	*2,628
Transportation for Life	29	51
Transportation for 14 Years	34	258
Transportation for 7 Years	500	3,631
Imprisonment, and severally to be whipped, fined, pilloried, kept to hard labor, &c.	2,049	12,587
Whipping—and Fine	147	992
Acquitted	1,233	7,930
No bill found, and not prosecuted	940	5,868
Of whom were executed	39	393

FACTS

Collected from Sir Fred. Morton Eden's pamphlet, On the policy and expediency of Insurance charters. London, 1806.

General view of property insurable in Great Britain.

Houses. (This head of items, must of course be taken from the preceding Census of 1801. T. C.)

Inhabited houses in England and Wales, 1,575,923.

In Scotland 294,553. In all 1,870,476. Uninhabited and building in England, 57,476. Scotland 9,537. Rental of houses, warehouses and manufactories, according to the estimate of Mr. Pitt, in his view of the income tax, six millions sterling; according to Dr. Beeke in his observations on that tax ten millions. (Dr. Beeke's observations on the income tax, is a book of great merit. T. C.) This at 20 years purchase, will be 200 millions. Add for machinery 40 millions, and the gross amount of insurable property of this description in Great Britain, will be 240 millions. Add for Scotland 30 millions, and the amount for Great Britain will be - - - - - 270,000,000

Furniture. England 120 millions. Scotland 15 millions. For the articles of cloaths, plate, books, jewels, houses, carriages, &c. in England and Wales 50 millions; in Scotland 5 millions. Furniture of Great Britain. 190,000,000

Agricultural Stock. Wheat consumed in Great Britain, Guernsey, Jersey, and Gibraltar. 8 millions of quarters (64 millions of bushels) at 40*s.*—Rye and Barley, (of which the distilleries take 500,000 quarters) 5 millions of quarters at 24*s.*

Oats and Beans, the produce of about 3¾ millions of acres, 12 millions of quarters at 16*s.* 8*d.* 32,500,000

Hay, Pease, Hops, Rape seed, &c. about 10 millions of acres.

Sheep from 32 to 38 millions in number in Great Britain.

Oxen about 3 millions. Horses about 1,100,000.

British Manufactures: home consumption 76,000,000

Exportation (real value), too low. T. C. 40,000,000

The items under this head, are thus noticed:

Woollens in 1800, consumed at home 11; exported 8 millions of pounds.

Cotton goods, consumed at home about 6 millions; exports on an average of 3 years in 1799, 4,175,231*l.*

Import of raw cotton about 30 millions of pounds.

Leather goods 12 millions.

Flax (Linen goods) Scotland, England and Wales about 2 millions.

Hemp 2: paper 1: pottery 2: glass 2: silk 3: hardware 6 millions.

Beer 200 Millions of gallons at 1*s.* or 10 million sterling.

Spirits 10 millions of gallons at 8*s.* or 4 millions sterling. This is the produce of half a millions quarters (4 millions of bushels) of grain, as appears by a report of the committee of the House of Commons, of 31 Dec. 1800.

Soap, consumed in 2,260,802 families in Great Britain $1\frac{1}{2}$ million.

Salt, 46,000 tons at 40 bushels each. Duty 10*s.* per bushel, 1 million.

Candles, 2 millions. Miscellanies 10 millions.

Foreign Merchandize. Imports in 1799, 32 millions; real value, 48 millions: of which East India goods amounted to 8 millions:	40,000,000
Works of Taste, Pictures, statues, &c. 10 millions	10,000,000
Shipping, worth 23 millions, of which $\frac{1}{4}$ insurable while in port	5,750,000
Sundries, Boats, coals, and other minerals, arsenals, &c. &c.	10,000,000
Total	674,250,000

Of all the above species of property, there is now actually insured (1806) two hundred and sixty millions. This appears from the taxes laid on the Insurance of property in 1797, 1802, and 1804, amounting to 2*s.* 6*d.* per pound. In 1785 the gross amount of property insured was 125 millions sterling. In Ireland about 10 millions is insured.

State of the Business transacted at the different Fire Insurance Offices.

Account of sums paid for duty by the principal Fire Offices for the Michaelmas quarter to Christmas, 1809.

Sun	*l* 22,258	15	10	Westminster	*l* 2,790	14	10
Phœnix	14,223	2	10	Eagle	2,682	13	9
Royal Exchange	12,774	8	1	Hand in Hand	2,427	18	7
Imperial	8,470	11	3	London	2,009	2	2
Globe	6,101	8	0	Atlas	1,699	7	0
Hope	4,455	17	0	Union	1,133	10	6
British	4,140	16	0				
County	4,120	13	2	Total	*l* 92,855	3	2
Albion	3,566	4	2				

WOOLLEN MANUFACTURE.

CALCULATION OF SOUTH DOWN WOOL.

[*By a Manufacturer*]

TO THE EDITOR OF THE COMMERCIAL MAGAZINE.

SIR, *August 5th* 1809.

HAVING lately read a very excellent speech of my Lord Sheffield's to the wool growers and dealers, at Lewes fair, on the 24th ult. wherein the sum of 3*s*. per lb. is stated to be a fair price for best South Down wools, and perceiving a calculation of a yard of broad cloath underneath, made from such wool, which is wholly founded in error, and calculated to mislead the public, as well as to do a serious injury to the whole woollen trade, I beg to annex what will be found a more correct statement of its value, supposing it to be made of the best South Down wool purchased of the growers, in the fleece, at the price quoted :—

	L.	*s.*	*d*
I will allow the manufacturer's expences as stated -		6	$1\frac{1}{4}$
Fleece wool purchased at 3*s*. per lb. of the grower cannot be rendered (the best not fit to make the cloth alluded to) for less than 6*s*. 6*d*. per lb. of which it will require at least $2\frac{1}{2}$ lbs. - - - - - - - - -	0	16	3
Dying a drab colour, as stated, at $3\frac{1}{2}d$. per lb. - -	0	0	$8\frac{3}{4}$
	1	3	1
Dying an olive, or brown, will be in addition - - - -	0	0	$6\frac{1}{2}$
	1	3	$7\frac{1}{2}$
A blue at 2*s*. per lb. will be in addition - - - - - -	0	3	9
	1	7	$4\frac{1}{2}$

Which will leave but a very *moderate* profit even for the manufacturers at 28*s*. per yard.

I should not have troubled you with the above, had I not seen so many misrepresentations in nearly all the public prints, which have done more injury to the woollen trade than most of the attempts of our enemies.

I am, Sir, your very humble servant,

A MANUFACTURER OF BRADFORD, WILTS.

Report of the Woolen Cloth Searchers in Yorkshire—from the 25th March 1810, to 25th March 1811, in the West Riding, the following return was made :—

NARROW CLOTHS.

This year	158,252 Pieces or	6,180,181	yards.
Last year	151,911	5,951,762	
Increase . . .	63,411	229,049	

BROAD CLOTHS.

This year	272,664 Pieces or	1,671,042	yards.
Last year	311,239	2,826,048	
Decrease . . .	37,575	1,155,006	

This diminution of the staple manufacture is to be traced to two causes; the prohibitory decrees of Buonaparte, and the Orders in Council of the British government; by the former of which our broad cloths are shut out from the continent of Europe, and by the latter our commercial regulations with the United States of America are suspended. Seeing the operation of these measures, and having their effects every way before our eyes in the number of artizans that are going about the streets without means of employment, we are not so much surprised that the quantity of woollen cloths have decreased so much, as that they have decreased so little, and this surprise will appear very natural, when the public are informed, that of 1160 shearmen in the town and neighbourhood of Leeds, 400 are out of employment. But a falling off of only 925,957 yards will be in some measure accounted for, when it is considered that the shipments to America for the fall trade in 1810, were as brisk as usual, and that for about six months in that year, the depot system prevailed as much as ever. *Com. Mag.*

GRAIN IMPORTED INTO GREAT BRITAIN.

Importation of foreign Corn and Flour, as laid before Parliament.—The quantity of foreign corn and flour as imported into Great Britain, from the 10th of October, 1809, to the 5th of January following, is 217,546 quarters of grain, and 72,755 cwt. of meal and flour. The aggregate quantity of corn and flour imported into Great Britain in 1809, is 1,482,758 qrs. of the former, and 565,938 cwt. of the latter; of which were imported from Ireland 853,556 qrs. of corn, and 74,993 cwts. of flour; and from all other countries, 629,202 qrs. of the former, and 490,945 cwts. of the latter. N. B. eight bushels make one quarter.

Importation of Corn for the last Ten years.—The following is an account of the value of corn and other grain, and flour imported into Great Britain (except from Ireland) from the year 1800 to 1810, both inclusive :—

Real value (at the average prices of the markets.)

1800	*l* 8,755,995	1806	*l* 1,106,540
1	10,149,098	7	1,878,521
2	2,155,704	8	336,460
3	2,164,592	9	2,705 496
4	1,855,333	10	7,077,865
5	3,754,831		

COTTON IMPORTED INTO ENGLAND.

West India Estates. It appears from a careful comparison of the circumstances relating to the real value of West India cotton estates, (taking every source of expense into consideration,) that the average value of each acre of land may be stated at between 140*l.* and 150*l.* sterling.

Each acre (as proved by an average of ten years) produces about 200 lbs. nett of cotton wool.

Upon an average of three years previous to 1808 (the two succeeding years being omitted on account of the American decrees and the unusual shortness of crops) the plantation expenses or those incurred before shipment came to 7*d.* per lb. The mercantile charges, including the duties (or those between the shipment and the sale), amounted to 7½*d.* per lb. So that the whole expense

upon every pound of cotton, which must be deducted from the gross proceeds of the sale, is 1*s.* 2½*d.*

But during the same period the average sale price has never exceeded 1*s.* 11*d.* per lb. which leaves, after all deductions, only 8½*d.* as the receipt of the proprietor.

Now it will readily be granted that, in speculations in which there is scarcely any risk, 10 per cent. upon the capital, after payment of all expenses, is the reward expected and usually received. Mercantile people know this too well to require conviction from argument. Whenever the hazard is increased, the premium to the advantages is proportionably augmented. Mr. Lowe, in his excellent pamphlet, has well insisted on the point. It will not be denied that speculations in transatlantic property, are precarious in an eminent degree. The uncertainty of crops, risk of health from climate, of property from the enemy, and various other causes, all render it so. Ten per cent. then, as the lowest reward of speculation, may be assumed as the minimum of return due to the cotton planter. This will be more easily conceded, as it is the general admission that this is the proper per centage of the sugar planter, and it is well known that sugar crops are much less affected by contingencies of weather, &c. &c. than those of cotton.

Assuming then ten per cent. as the reward of the planter, the value of each acre to be 140*l.* sterling, and the quantity of cotton produced to be 200lbs., the nett receipt of the planter on each pound of cotton wool should be 1*s.* 5*d.* but the actual sum he receives is 8½*d.* a certain loss to him of 8½*d.*; for if it be once granted, as it undoubtedly must, that 10 per cent. is the fair premium, all below it may be considered as taken out of the funds of the proprietor.

Such is the state of the British cotton-planter. That of his North American rival is much superior. Situate in the midst of the necessaries of life, he depends on himself or his neighbours for support. He purchases land at a cheaper rate, and imports his negroes at an inferior expense. Every thing diminishes the intrinsic cost of cotton properties in the United States, and the regulations of Great Britain increases the value of the produce. The limits of this essay do not permit further details; but should circumstances allow, they may perhaps be laid before the public. At present it may suffice to state that if the North American planter netts 6*d.* per pound he can afford to cultivate cotton. Now the expenses of cultivation, of navigation, &c. are very trifling. Hence he can always undersell the British planter.

Similar local adventitious advantages operate in favour of the Brazil planter, and his receipts from the greater fineness of his produce, are still higher.

Table of Cotton imported annually into Great Britain, from 1797 *to* 1810.

Year	British.	N. America.	Brazil.	Foreign, generally.
1797	6,918,153lbs.			
98	7,909,832			
99	7,529,882			
1800	10,611,349			
1	11,261,014			
2	*8,799,891			
3	5,660,615			
4	20,529,878			
5	21,146,870	34,798,120lbs.	8,198,720lbs.	865,100lbs.
6	19,383,580	34,745,760	7,648,320	2,918,136
7	22,653,270	47,732,440	2,926,880	3,889,740
8	18,168,270	10,435,600	7,622,720	4,843,080
9	19,095,980	41,477,520	23,467,200	14,396,110
10	———	———	———	———

The condition to which the cotton planter is reduced, as well as the nature of his claims, having been already stated, the next object of attention is his former situation.

Although the annual average price fluctuated very considerably from the commencement of 1781 to the year 1788, it was never less than 1*s.* 11*d.* per lb. while, in a majority of years, it exceeded 2*s.* making a total average of 2*s.* 2$\frac{5}{8}$*d.* per lb.

During the next eight years, from 1788 to 1796, the political derangements of Europe produced severe consequences to the colonists. In 1789, cotton wool fell to an average of 1*s.* 5*d.* In the subsequent years it rose as high as 2*s.* but was very unsteady. The average of the whole term was a fraction more than 1*s.* 6*d.* per lb.

The horizon of the planter seems to have been illumined for the next five years, until 1801: for the minimum of the annual

* The extraordinary diminution of these two years, arose from the cession of the colonies of Demerara, Issequibo, Berbice, and Surinam, to Holland; and from the war, which confined the importation to our own produce. On the re-capture of the above-named colonies, the quantity immediately increased.

average was, during that time, 2*s*. 7*d*. and the maximum 3*s*. 1*d*., and the total average 2*s*. 7½*d*.

In the year of peace it fell to the average of 2*s*. From that year to 1807, it fluctuated between 1*s*. 10½*d*. and 2*s*. 2½*d*. averaging, upon the whole, 2*s*. per lb. sterling.

The prices during 1808 and 1809 were better, but cannot be admitted into a general statement, as they originated in causes so novel and unnatural, that a recurrence of them cannot be expected during another century.

The average of the current year is below 1*s*. 10*d*. and will probably be still less, as the quantity imported of foreign cotton is rapidly increasing. The natural consequence of which is a diminution of price.

From 1781 to 1788 inclusive, cotton wool, as has been already remarked, sold on an average at 2*s*. 2⅝*d*. At that time no duties were levied. Every article required by the colonies was much cheaper. Navigation charges were equally small; and the peace which then existed, favoured the manufactories at home, which benefited the planter.

The actual expenditure was, of course, much inferior to what it now is, while the price was higher.

It may be assumed, as a broad and incontrovertible fact, that the price of every article is double what it was in 1781. The plantation charges may therefore be stated at one-half of what they are according to a preceding statement, that is at 3½*d*. per lb. of cotton wool; and supposing the mercantile charges to have been the same as they now are, they, after deduction of 2*d*. for the duties, are 5½*d*. per lb. Thus, the gross charges upon every pound of cotton wool, would then have been 9*d*. which leaves 1*s*. 5⅝*d*. of actual receipt to the planter of that time.

Lest this mode of estimating be not admissable, let another be adopted, and the results will be found nearly the same. Among mercantile people, 4*d* per lb. was generally supposed sufficient to cover all the difference between war and peace charges. This, it must be remarked, was previous to the present war, since which the duty has been nearly doubled on British cotton. About 1*d*. per lb. may therefore be added to the estimate of the merchants, which increases it to 5*d*. per lb. When this is deducted from 1*s*. 2½*d*. the present expenses, 9½*d*. will remain as the real expense of the former period; and the additional half-penny may be considered equivalent to the enhanced price of every necessary for the estates, though it is in fact below it.

The cotton-planter of these eight years received 1*s*. 5½*d*. which, from the diminished value of money, was equal to at least one-half more than it now is.

The second period, though less favoured in point of actual receipt, was equally so by the inferiority of every description of expense, and by the non-imposition of duties, as the gross proceeds of sale averaged a fraction more than 1*s*. 8*d*. per lb. The clear receipt was therefore about 9*d*. Had the (W. I.) planter not been favoured, as he fortunately was, the fate which now seems to impend over him would have been then accomplished, and with less destructive effects to the state. It has been his lot to have his hopes raised to the highest pitch, and then, by a refinement in cruelty, to have them dashed away with the rudest violence.

The expenses were somewhat increased from 1796 to 1802, about the middle of which (in 1799) a duty of 8*s*. 9*d*. per 100 lbs. or of a fraction more than 1*d*. per lb. was imposed on British cotton wool; while, strange to tell, 6*s*. 6*d*. per 100 lbs. or about three farthings per lb. was laid on American produce in American bottoms. The average price was 2*s*. 7½*d*. If the whole expense amounted to 1*s*. 2*d*. which it certainly did not, the planter netted 1*s*. 5½*d*. which was quite equal to his wants or his wishes.

The diminution of charges during the short-lived peace of Amiens, remedied, to a certain extent, the smallness of the price, which was only 2*s*. per lb. They were about 10*d*. per lb. which left 1*s*. 2*d*. for the proprietor.

From the renewal of hostilities to 1808, while 2*s*. per lb. has been the average price of cotton wool, every thing has happened to diminish the planter's funds. For, immediately on the breaking out of the war, a duty of 10*s*. 6*d*. per 100 lbs. or 1¼*d* per lb. was laid on British, and 7*s*. 10*d*. per 100 lbs. or three farthings and a fraction, on American cotton in American bottoms.

In 1805, this highly improper distinction in favour of the latter ceased, and the duties were increased to 16*s*. 8*d*. per 100 lbs. or 2*d*. and a fraction per lb. on British, and 17*s*. 8*d*. per 100 lbs. or about 2½*d* per lb. on American produce.

Both, however, are on equal terms when the latter is imported in British bottoms. The duty on British produce was in the following year raised to 16*s*. 10*d*. and has continued steadily the same; that on American cotton was first (in 1808) raised to 17*s*. 10*d*. per 100 lbs. or 2¼*d*. per lb. and lately to 20*s*. 5*d*. per 100 lbs. or about 2½*d*. per lb. when imported directly, and 21*s*. 1½*d*. per 100 lbs.

or a fraction more than $2\frac{1}{2}d.$ per lb. when imported indirectly. The former inequality, when imported in British shipping, is still retained.

The Brazilian cotton growers enjoy similar privileges, when they employ British vessels; but pay 1*l.* 5*s.* 2*d.* per 100 lbs. or 3*d.* per lb. in their own shipping.

The British cotton proprietors have therefore been receiving only 10*d.* per lb. during that period, which, however inadequate, is superior to his present receipt, and would not have been so high had the average been made only for the three last years, excluding 1808 and 1809 for the reasons already assigned. It has been shewn to have been no more than 1*s.* 11*d.*

Before this part of the subject is closed, it may be worthy of attention to refer to the table, in which a statement is given of the quantities of cotton imported into this country. From 1804 to the present time, the British have steadily averaged about twenty millions and a half of pounds, while America vacillated from ten millions and a half to forty-seven millions and a half, as caprice dictated. The increase is going on; and early in May, it was one-fifth more than it had been last year.

The Brazil cotton has suddenly increased from seven millions and a half of pounds to about twenty-three millions and a half.

That from India, &c. from about four and a half to fourteen millions and a quarter of pounds.

These facts need no comment; they speak for themselves on terms too unequivocal to be misunderstood.

Importation of cotton wool.—Some idea may be formed of our cotton manufactures by a glance at the report of cotton wool imported into this kingdom during the two last years; an article which we know the (British) markets are not glutted with, neither does it form an article of exportation in its raw state: the great increase of the cotton manufacture from its cheapness over that of linen, must in some measure be a compensation for the defalcation of the manufacture of the latter, at least by an equal provision of labour, although the trade is diverted into a different channel from the original.

Importation of Cotton Wool in 1809 *and* 1810.

From whence.	London.	Liverpool.	Glasgow.	Total 1810.	Total 1809.	Increase.	Decrease.
	Bags.	Bags.	Bags.	Bags.	Bags.	Bags.	Bags.
Heligoland	182	- - -	- -	182	- - -	182	- -
Iceland	15	5,177	- -	5,192	4,824	368	- -
*Portugal	70,450	71,190	1,827	143,467	146,212	- - -	2,745
Spain	2,696	3,938	- -	6,634	8,699	- - -	2,065
Mediterranean	2,612	1,145	- -	3,757	11,112	- - -	7,355
East Indies	79,382	- - -	- -	79,382	33,764	45,618	- -
Africa	- - -	22	- -	22	- - -	22	- -
North America	18,557	191,458	21,828	231,843	143,717	88,126	- -
West Indies	7,944	17,606	14,443	39,993	55,663	- - -	15,670
Demerara and Berbice	2,287	21,008	10,225	33,720	21,178	12,542	- -
Surinam	3,525	1,358	- -	4,883	3,704	1,179	- -
Import. in 1810	187,650	313,102	48,323	549,075	428,873	148,037	27,835
do. 1809	125,870	266,952	36,051	428,873	- - -	- - -	- -
Increase	61,780	46,150	12,272	120,202	- - -	- - -	- -

Total increase 120,202 bags, not including, during the same period the importations at the ports of Bristol and Lancaster, which amounted to 3,449 bags."

I give the preceding tables, for the purpose of showing what exertions Great Britain is making, to render herself independent of the supply of cotton from the United States. Should peace arrive to-morrow, Great Britain, by means of the East Indies, the West Indies, and Brazil, could nearly furnish all the cotton required for her immense manufacture. The plain inference is, that if we do not manufacture our cotton at home, we cannot dispose of it abroad. I know of no manufacture that can be set up with such decided advantages, as that of plain coarse muslins, shirting muslins, and nankeens; and calicoes printed by roller-work. The raw material of the woollen manufacture is daily becoming more scarce and dear: the raw material of the cotton manufacture is daily becoming more plentiful and cheap, or may be made so. You cannot suddenly raise sheep to answer a great demand: you may raise cotton sufficient in one season. Let the cotton-growers look to this: it is *their* business, because it is their interest, to push the cotton manufacture at home to the utmost. Great Britain is very wisely endeavouring by all means in her power to become independent of America, as to the importation of *raw* cotton: why should

* Including the Brazils.

not America pursue a similar policy as to *manufactured* cotton? until the cotton manufacture is established here, peace will bring but little relief to the cotton-grower of the southern states. T. C.

CULTIVATED AND UNCULTIVATED LANDS OF GREAT BRITAIN.

The following table, is from a report of the committee of the house of commons in 1795, but I do not know of any thing more authentic since.

General view of the extent of the island of Great Britain, and the proportion between the waste and uncultivated, and the cultivated parts thereof.

	Acres,
	Uncultivated.
England and Wales - - - -	7,888,777
Scotland - - - - - -	14,218,244
	22,107,021
	Cultivated.
England and Wales - - - -	39,027,156
Scotland - - - - - -	12,151,471
	51,178,627
	Total Extent.
England and Wales - - - -	46,915,933
Scotland - - - - - -	26,369,695
	73,285,628

Of the value of the waste lands of England, were they cultivated to that degree of improvement, of which they are capable, it is difficult to form a correct idea.—We shall submit, however, some data as the basis on which to ground future calculation. Allowing that there are twenty-two millions of acres of uninclosed lands in the kingdom, the whole of these may be divided in the following manner:

	Number of Acres.
Lands incapable of improvement - -	1,000,000
—— proper for plantations - - -	3,000,000

—— for upland pasture - - -	14,000,000
—— for tillage - - - - -	3,000,000
—— capable of being converted into meadow, or water meadow - -	1,000,000
Total	22,000,000

The million of acres, stated to be incapable of cultivation, are here estimated as of no annual value.

The three millions of acres, fit for plantations, may be computed to be worth eight shillings per acre, or in total, 1,200,000*l.* per annum; (annual produce and not rent).

The fourteen millions of acres of upland pasture, when improved, may be calculated as worth five shillings per acre of rent, or 3,800,000*l.* per annum.

The three millions of acres, convertible into arable land, would, when inclosed, average, at least, ten shillings per acre, or 1,500,000*l.* per annum.

The million of acres convertible into meadows, or water meadows, may be estimated at 1*l.* 10*s.* per acre, or 1,500,000*l.* in total.

The total annual produce would then amount to 20,700,000*l.*

POOR OF ENGLAND.

In one way or other about one ninth of the population of England, in 1812, received parish assistance. The returns of the amount of poor rate are to be made duennially to parliament. In 1803 the poor rates amounted to somewhat more than 5¼ millions sterling. I have not seen the return for 1813.

GENERAL STATISTICAL TABLE, 1812.—*No. I.*

The following table has been formed, after much labour, expressly for this work, for the purpose of *general* reference. We are aware that it is incorrect in many particulars, but on the whole it may be accepted as approaching pretty nearly to truth, so far as facts can be discerned in the varied statements of the learned and scientific. And it may serve the *ordinary* purposes of our readers.—*Niles' Reg.*

The whole globe is estimated to have a surface of 148,510,627 square miles—of which the habitable portion is said to have 38,990,569 square miles, and supposed to contain 760 millions of inhabitants.

Asia, is computed to have	10,768,823 sq. miles, &	500 millions peo.
Europe,	2,749,349	160 millions.
America,	14,000,000	50 millions.
Africa,	9,576,208	50 millions.

☞ These estimates are very arbitrary. As to the contents and population of *Asia* and *Europe* the various authors consulted are nearly agreed—but while some of them swell the population of *America* and *Africa* to 150 millions each, there are others who depress them as low, respectively, as 20 or 30 millions. The "*unknown parts*," added to the last given calculations, is supposed to make general content of the *habitable world*, as stated.

The Chinese empire is the most populous, but the Russian the most extensive. The United States have the second rank as to the nominal contents of their territory.

Pekin, *Nankin*, and *Jedo*, rivals in population, are the greatest cities of *Asia*, and are said to have 3 millions of inhabitants, each.

London is the most populous city in *Europe*—by the census of 1810, it contained 1,099,104 inhabitants, of whom 483,781 were males, and 613,323 females.

Mexico is the largest city in *America*; by the census of 1794 it had 112,929 inhabitants, and its population has since considerably increased. *Philadelphia* and *New York* are the next in rank in the new world.

Grand Cairo is the best peopled *African* city of which we are informed—it is computed to have more than 300,000 inhabitants, but there are some reasons to believe that, in the interior, are several cities far more populous, of which we know little at present but from vague rumor—viz. *Tombuctoo* and *Houssa*: the former is said to contain 2 millions of inhabitants.

Empires, Kingdoms and States.		Square miles.	Whole Population.	Capital cities; population.		Inhab. to a sq. mile.	Revenue in millions of $	State tax per head. $	cts.
Empire of China	(A)	1,749,000	383,000,000	Pekin	3,000,000	212	300		79
Russia	(B)	4,900,000	47,440,000	St. Petersburg	180,000	9	60	1	05
France	(C)	236,840	43,423,000	Paris	547,756	184	160	3	06
Japan	(D)	118,000	30,000,000	Jedo	3,000,000	254			
Austria	(E)	131,740	15,519,625	Vienna	250,000	118	32	2	07
Turkey	(F)	960,000	22,000,000	Constantinople	500,000	21	50	2	27
Persia	(G)	800,000	10,000,000	Ispahan	100,000	13			
Birman	(H)	250,000	17,000,000	Ummarapoota		68			
The British Kingdoms	(I)	104,656	16,552,144	London	1,099,104	158	355	21	50
By other statements (T. C.)		156,250	16,552,144			106			
Kingdom of Spain	(K)	150,000	10,327,800	Madrid	150,000	67			
Portugal	(L)	27,280	1,838,879	Lisbon	230,000	69			
Naples	(M)	22,000	4,000,000	Naples	380,000	181			
Denmark	(N)	163,041	2,148,438	Copenhagen	100, 00	13	7	3	21
Sweden		160,000	2,353,353	Stockholm	72,000	15	$6\frac{1}{2}$	2	70
Prussia	(O)	44,464	4,559,556	Konigsburgh	50,000	103			
Westphalia	(P)		2,912,303	Cassel	25,000		$5\frac{1}{2}$		
Bavaria		26,176	3,231,570	Munich	40,000	124	8	2	78
Wirtemburg			1,183,300	Stutgard	20,000		3		
Saxony			2,085,476	Dresden	60,000		$5\frac{1}{5}$		
Sicily (island)		10,000	1,500,000	Palermo	180,000	150	$1\frac{1}{2}$	1	00
Sardinia (island)		6,600	456,990	Cagliari	25,000	69	$\frac{1}{2}$	1	00
Grand Duchy of Warsaw	(Q)	27,312	2,277,000	Warsaw	60,000	84	3	1	40
United States of America	(R)	2,000,000	7,239,902	Washington	8,208	4	14	2	00
Confederation of the Rhine	(S)	113,424	15,577,344	———	———	138	$38\frac{1}{2}$	2	49

(A) This includes all the tributary or dependent states. China proper has about 1,200,000 square miles, and, according to *Sir George Staunton*, 333 millions of inhabitants, or 300 to a square mile. This great population admitted, it may be said, *that one half of the whole people of the world we inhabit, obey the Chinese sceptre.*

(B) Russia, in Europe, contains 1,400,000 square miles, inhabited by about 41 millions of people, or 35 to a square mile—their Asiatic possessions are very thinly populated, vast regions being hideous desarts, destitute of fixed inhabitants. The revenues of *China* and *Russia* appear very moderate, compared with their population. But there is nothing more uncertain than the idea we commonly hold of money; its *value* is as various as any thing else. The only way to scale its worth, is by ascertaining the quantity of *labour* it will purchase. In China, for instance, from 12 to 15 days labour, may be obtained for the same nominal amount that a person, at the same business, (be it what it may) would earn in the United States in one day—money is, therefore, 12 or 15 times as valuable in China as it is here. In Russia it is from 8 to 10, for one in the United States. Money is, perhaps, of *less value* with us than in any other country, even in the countries which produce it, Mexico and Peru. We have an idea of a *money-metre*, to shew, by the price of a *day's labour*, the relative value of it in various parts of the world. We may form a table for this purpose.

(C) Travellers having agreed that Japan is as populous as China, have estimated its inhabitants at 30 millions; the apparent difference in the table arises, in part, from Tartary being taken into the general estimate of the latter country, thus reducing the ratio for each square mile; and in part from the deductions made from the surface of the former, for mountainous or barren districts.

(D) France, proper, 148,840 square miles; Holland, the Netherlands, and the former possessions of several petty German princes, 20,000 square miles; the kingdom of Italy, with Istria, Dalmatia, &c. about 50,000 square miles; all which, with Piedmont, Savoy, the former country of Nice, now forming *departments of France*, make up the aggregate. (See next table. T. C.)

(E) Before her late wars with France, Austria possessed 226,876 square miles; 26,970,030 inhabitants, and a revenue of 48,244,000 dollars.

(F) Turkey, in Europe, 9 millions; in Asia, 10 millions; and in Africa 3 millions of inhabitants. Immense regions of country are

desart. The population, as well as the revenue, are mere suppositions.

(G) This country appears to have decreased in its population; caused, perhaps, by the dreadful civil wars that have frequently ravaged it. Besides, there is much mountainous and barren and unproductive land. The revenue is paid in *kind*.

(H) Including Ava, Pegu, Malacca, &c. Ummarapoota is the new capital, but little known to Europeans. The ancient and once magnificent cities of Ava and Peru, are said to be nothing but heaps of ruins.

(I) England and Wales, 49,450 square miles; Scotland, 27,749 do. Ireland, 27,457. By the census of 1810, England contained 9,499,408 inhabitants; Wales 607,380; and Scotland 1,804,864, to which they add for the army and navy 640,500—making a grand total of 12,552,144. We have not seen an enumeration of the people of Ireland—from the accounts laid before parliament, there are probably about 500,000 dwelling houses; averaging them at 8 inhabitants each, we have a gross aggregate of four millions; which is probably about the true amount. The revenue, as here stated, is required for the *present year* 1812, *independent of loans*. It may emphatically be called the *land of taxation*.

[Arthur Young, secretary to the board of agriculture, than whom I know no more competent authority whether for knowledge of the subject, industry, or talent, in vol. 1, p. 283, of his Tour to France and Italy, qto. states his reasons for assigning the following proportions of land to the general divisions of the British Empire in Europe.

England	46,915,933	acres, equal to 73,306 square miles of 640 acres to a mile.
Scotland	26,369,695	
Ireland	20,649,961	
	99,335,589	

99,335,589 or in round numbers 100 millions of acres, equal to 156,250 square miles. The calculation adopted by Mr. Niles from Pinkerton, is from Templeman's Geography, which is generally too low. Dr. Grew in the Philosophical transactions No. 330, page 266, calculates the real contents of England and Wales at 46,080,000 acres, which is very near Arthur Young's estimate. Arthur Young and Neckar, calculated France in their time just before the revolution, at 131,722,295 acres, and the population at 26,363,074, or 5 acres per head. See 1 Young's French Tour, 464.

The committee of the house of commons appointed to enquire

concerning the waste lands of Great Britain, in their report of December 23, 1795, stated them at 73,285,628 acres; of which 51,178,627 are cultivated, and 22,107,001 uncultivated. Add 26,049,961 for the acres of Ireland, and the total of England, Scotland and Ireland, will be the same as above, viz. 99,335,589, which shews that they adopted Arthur Young's estimate. Of these uncultivated lands they state as incapable of improvement, one million: lands fit for planting 3 millions: fit for upland sheep pasture, 14 millions: fit for tillage 3 millions: and one million of meadow land. As I know of no authority on this subject that is entitled to so much credit as Dr. Grew, Arthur Young, and the committee of the British legislature, I adopt their calculations, as by far the best evidence we now possess. I have no means of checking this by the agricultural reports of the several counties. I regard the following method used by Mr. Paucton, as one of the best for calculating by a map. On a good map of Great Britain for instance, make an accurate border of wax or dough; lay the map evenly on a table; fill up the interstice with very small shot; weigh the quantity required. Then make a border round some certain portion of which the contents are known, as Middlesex: and the comparison of the weights of the shot, will give with tolerable accuracy, the square miles or acres. T. C.]

(K.) Such was Spain before the invasion by Bonaparte. Its population, has, doubtless, greatly decreased—of the present revenue no estimate can be made; under the old monarchy it was said to amount to 25 millions—or $2 for each head.

(L.) The preceding remarks on Spain also apply to Portugal. The revenue of the crown, the chief of which, however, was derived immediately from Brazil, was estimated at twelve millions per annum.

(M.) The revenue derived by the 'king of the two Sicilies,' from Naples, before his expulsion from the continent, was about 5 millions.

(N.) A very considerable part of the dominions of Denmark, is contained in the mountains of Norway, and frozen regions of Lapland. The provinces of Denmark proper are well populated; and the whole amount of Danish subjects at this time, propably exceeds two millions and a half, great improvements in the condition of the peasantry being latterly made.

(O.) Prussia, before the late war with France, possessed 88,930 sq. miles, with a population of 9,015,130 inhabitants; and the

revenue was about 15 millions of dollars. Its present resources are unknown.

(P.) Westphalia, Bavaria, Wirtemburg and Saxony, are kingdoms lately erected by the emperor of France. They form a part of the "confederation of the Rhine" noticed below.

(Q.) The Grand Duchy of Warsaw, is a power created by France, at the expence of Prussia and Austria, who aggrandized themselves at the expence of the Poles. It has lately been said that this country will be *honored* with a king.

(R.) Including Louisiana—a vague estimate. The population of the eighteen *states* is equal to about 12 persons to a square mile. Our revenue, derived from duties on imports, is constantly fluctuating—we have put it at 14 millions, being about what it would at this time amount to in a *regular* course of things.

(S.) "The confederation of the Rhine" is an association of many petty kingdoms and states, brought about by France, with the chief view (as it appears to us) of acting as a barrier to Austria, Russia, &c. and of otherwise aiding the emperor in his wars.

☞ Blanks are left in those places we could not fill up with *satisfaction*, at present. When better information is afforded, we shall convey it to our readers, and they may complete the table with a pen.

I have taken the preceding table from 3 Niles's Reg. 121, adding the note included in Brackets. This was published in 1812. Niles's Register is a paper that pays much attention to statistical documents, and is therefore valuable.

GENERAL STATISTICAL TABLE, (No. II.)

Of Great Britain and Ireland, France, Austria, Prussia, and Spain.

	For the year 1792.					For the year 1812.	
	Great Britain and Ireland.	*France.*	*Austrian Dominions.*	*Prussia.*	*Spain.*	*Great Britain and Ireland.*	*France.*
Extent in square miles	156,000	200,000	240,000	75,000	200,000	156,000	236,840
Population - - - - - - -	15,000,000	26,000,000	20,000,000	6,000,000	12,500,000	16,522,144	43,423,000
No. of persons per square mile	100	125	83	80	62	106	184
Extent in English acres - -	100,000,000	132,000,000	143,600,000	48,000,000	128,000,000	100,000,000	151,577,600
Number of acres to each person	$6\frac{1}{2}$	5	7	8	10	6	$3\frac{1}{2}$
Revenue (Taxes) in Dollars	120,000,000	90,000,000	44,000,000	19,000,000	64,000,000	355,000,000	170,000,000
Amount of public debt in Dolls.	1,800,000,000	1,125,000,000	180,000,000	- - -	220,000,000	2,800,000,000	- - - -
Army in peace - - - - - -	45,000	225,000	360,000	225,000	100,000	- - - -	- - - -
Army in war - - - - - -	150,000	500,000	450,000	350,000	250,000	400,000	800,000
Seamen in peace - - - - -	18,000	- - - - -	- - - -	- - - -	40,000	- - - -	- - - -
Seamen in war - - - - - -	110,000	- - - - -	- - - -	- - - -	100,000	150,000	- - - -
Cultivated acres - - - - -	68,000,000	75,000,000	75,000,000	25,000,000	50,000,000	68,000,000	110,000,000
Taxes per head in Dollars	8	$5\frac{1}{2}$	$2\frac{4}{10}$	$3\frac{16}{100}$	5	$21\frac{1}{2}$	4
Population of the Capital - -	900,000	550,000	250,000	80,000	150,000	1,100,000	600,000

The above table of approximating round numbers, is altered by me, *on a review of authorities*, from a similar table in 2 Niles's Register, 232. The English debt at the close of 1812 I have taken at 850 millions, and deducted 220 millions as paid off by the Sinking fund to the end of that year. There was actually paid off to Aug. 1st. 1811, *l* 215,293,354. The French expose or budget, for 1811, made the taxes of that year amount to 954 (or as I add them) 964 millions of Francs. I believe the above table to be near the truth in all the important particulars for the periods assigned. Every year alters the state of things:

even while I am writing, the power of Buonaparte seems near its close. But the value of the *facts* will remain the same. The philosopher will ask himself, what causes produced the difference between 1792 and 1812? What causes have produced the difference between 1812 and 1814? What part of the statement is likely to be permanent? T. C.

BANKS.

Belzebub engendra *Law*,
Law engendra la Banque,
La Banque engendra Mississippi,
Mississippi engendra Systeme,
Systeme engendra Papiers,
Papiers engendrerent Billets,
Billets ont engendrè Agiot,
Agiot engendra Larrons,
Larrons engendrerent Souscription,
Souscription engendra Dividende,
Dividende engendra Intrinseque,
Intrinseque engendra Argent-fort,
Argent-fort engendra Compte-ouvert,
Compte-ouvert engendra Registre,
Registre engendra Billon,
Billon engendra Zero;
Zero,
Zero s'est enfin trouvè impuisante.

I shall have occasion to say something by and by about BANKS, in mean time I must collect materials and facts, and make a few preliminary observations. The publications of Dr. Bollman on Banks, viz. paragraphs on Banks; and the letter to Alexander Baring, Esq. on the currency of Great Britain, in the second volume of Walsh's American Review, are tracts of sterling merit. I shall probably vary from Dr. Bollman, in my views of the subject.

For the present I shall briefly state the nature of the Bank-establishments of Great Britain.

There is in that country, but one incorporated Bank, the Bank of England, liable by law no further than the amount of their incorporated capital. There are *now* nearly nine hundred provincial banks, of which the partners are individually responsible as in all other cases of partnership, for the debts of the firm. The setting up of any firm, or joint stock company, and selling or transferring shares therein with pretence of liability no further than the joint stock, is made a punishable misdemeanor, by the act of 6 Geo. 1 ch. 18, § 18, called the *Bubble act*. See the *King* against *Dodd*, 9 East, 516; and *Buck* against *Buck*, 1 Campb. N. P. Rep. 546.

The Bank of England was incorporated in 1694, and its capital in 1746 enlarged to 10,780,000*l*., which by accumulated profits has so encreased, as to be lately reckoned at 17 millions sterling.

This Bank, receives deposits, issues notes, discounts bills at sixty and ninety days, and advances money to government; who hold permanently 11,626, 00*l*. of the bank capital, as a loan, for which they pay interest.

Bank notes are promissory notes payable on demand in the current coin of the nation, which formerly was silver, but is now gold. Bank notes were usually paid in guineas, till 26 Feb. 1797. But during the year 1796 the calls for cash were so frequent, that the coin and bullion in their vaults scarcely amounted to a million and a half sterling. To lessen this demand, they lessened their discounts from 11 millions to 8 millions; their discounts varying from 8 to 14 millions. On the 6th Dec. 1800, the amount of Bank of England notes in circulation was 15,450,970*l*. in 1810, 21,406,930*l*. at which time the notes of private bankers was estimated at four times as much. This great demand for cash was attributed to the alarm of invasion, and had it gone on, the bank must have stopt payment. On this occasion, government, by the *Restriction act* of 1797, made the bold experiment of ascertaining whether the national business, private and public, could not be conducted without coin, by means of the paper credit of the country, which every individual in it, had an interest in supporting. They forbad the Bank to pay out any more coin: and hitherto the experiment has succeeded. On 24th July, 1811, the act passed making Bank notes a legal tender. Much controversy in and out of Parliament has arisen of late years as to the cause of the increased value of gold and silver, which the committee of the British legislature, has attributed to the stoppage of cash payments, the encreased

emission of bank notes, and the hoarding of coin by individuals from distrust occasioned by the two former measures.

I do not coincide in this opinion: for I do not believe the circulating bank notes, form one-tenth of the circulating medium, by means whereof, the trade-operations, internal and external, of Great Britain, are managed.

The Provincial Banks of that country were in	1793	280
	1797	230
	1810	796—878
	1811	880

In December, 1810, they were thus arranged.

Country bankers in England who issue their own notes		613
ditto	Wales - - - - - - -	25
ditto	Scotland, including branch banks,	83
ditto	London and Westminster - - -	66
ditto	Ireland - - - - - -	85
Isle of Man, 1.	Guernsey, 3. Jersey, 2. - -	6
	Total	878

For the most part, these provincial bank notes, promise to pay in bank notes of the bank of England at London.

The trade of the nation, both in Great Britain and America, is carried on, 1st. In a small degree, and in all petty transactions, by cash: banks have the sure and constant effect of driving out of circulation, all cash except what is necessary for current expences of a minor description. 2dly. Bank of England notes. 3dly. Provincial Bank promissory notes. 4thly. Transfer of credits on bank books. 5thly. Transfer of bills of exchange and promissory notes. 6thly. Somewhat in Great Britain and largely in this country, by accommodation notes, or mutual loans of draughts and indorsements, not founded on any real transaction. In England these are greatly discouraged: in this country, they are greatly encouraged.*

Each of these sources of circulation, may answer the purpose of a medium much beyond its nominal amount. Thus, a bank note of ten pounds, or ten dollars, may pass through ten hands in the course of a day, and thus become the representative of transactions to the amount of a hundred.

The transfer of government securities, bank stock, &c. is rather a particular species of trade, than a mode of payment.

* The whole paper circulation of Great Britain and Ireland was calculated (October 1810) at 4,500 millions of dollars; and the whole annual income of the nation at 250 millions of pounds sterling.

Now I cannot conceive that any alteration in the issue of bank of England notes which bear so very small a part, in amunot, in the circulation of the trade of the country, can produce the great enhancement in the price of bullion, which has lately taken place: doubtless some part of the effect is owing to that cause, but assuredly not the whole of it. That encrease depends on many circumstances.

1st. As every commodity will rise in price in proportion to its scarcity, some part of this encrease must be owing to the hoarding up of coin: an effect however gradually diminishing in England.

2ly. The restriction act, has also tended to produce a scarcity of coin, which can now no longer be obtained at the bank for bank notes.

3ly. The wants of the army and navy, take away a great deal of actual cash.

4ly. The sources of bullion supply from Spain and Portugal, have not been so abundant as heretofore, owing to the calamitous situation of these countries.

5ly. The exchange of late years has not been favourable to England: and this calls for cash to pay balances of mercantile transactions.

6ly. Prodigious quantities of coin have been exported, partly on a bullion speculation, and partly to purchase grain, an article of the first necessity. On the 26 July, 1811, lord Sheffield at the Wool fair at Leeds, stated that the value of grain imported into Great Britain in 1800 and 1801, amounted to 19 millions sterling.*

*" IMPORTS.—From a return just presented to the House of Commons, it appears that we imported in 1810

1,387,200 Quarters of Wheat,
533,613 Cwt. of Flour,
503,122 Quarters of Oats, and
33,226 Bolls of Oatmeal.

Of this quantity the imports were—

From France, 334,806 Quarters of Wheat, and 202,922 Cwt. of Flour.

From Holland, 189,016 Quarters of Wheat,
From Germany 145,186 do. and
From Poland and Prussia, 296,756,
From Denmark and Norway, 110,935 Qrs.
From America, 34,829 Quarters of Wheat, and 210,209 Cwt of Flour.

Hence *more than one-third* of the Wheat, and nearly *one-third* of the Flour, came from France and Holland; while from Ame-

It is to all these causes together, that the scarcity of coin is owing; and therefore they furnish no reason whatever why the bank should be again compelled to pay in specie. The prohibition was a very bold measure, but under the circumstances, in my opinion, a very wise one.

But the paper system of that country has undergone a change, which totally alters the nature and complexion of it; and will certainly at some time or other shake to the foundation the whole system of paper credit.

The current medium of England was formerly, the current medium of the world: viz. silver and gold. These were representatives of articles that constituted wealth: that is, of those articles which by exchange could command labour, which is the only universal exponent or prototype of wealth. Then, paper money, on account of its facilitating the operations of trade, supplied in a great degree, and dispensed with gold and silver; but paper money for a long time, remained the exponent or representative of real coin. It is no longer so. It is now, not the representative of real coin which in England is nearly banished, but of *personal credit;* that credit being deemed the exponent or representative of actual, valuable, convertible property, real or personal, which it may be or may not be; but in that country it is so in a reasonable degree. The circulating medium of England then, being no longer the circulating medium of the rest of the world, this state of things will continue and only continue, while the course of exchange remains favourable to that country, or the surplus profits of internal commerce, after maintaining the people, and paying the taxes, is sufficient to counterbalance any unfavourable state of foreign trade. For it is upon its internal commerce that England must ultimately depend: she is rich, not by her foreign trade, but in spite of her foreign trade. But those who guide the helm of that national vessel, are running very close to the wind.

The standard or bank price of gold being *l* 3 17 10½, the paper price of it at the close of 1812, was *l* 5. 8. 0.

In this country, bank paper is not upon so good a footing as in England. The maxim here is, to bring dead capital into activity.

rica we imported not more Flour than we did from the countries with which we are at war; and the quantity of Wheat from America did not exceed one-fortieth part of the whole quantity imported."

which to a moderate degree is good. But under this notion, banks are created, and paper money issued indefinitely: and it is encreasing to such an extent, that its gradual depreciation is unavoidable, as the reader may well judge from the table, that I shall give in my next. Nobody supposes for a moment now, that a bank note of any kind, is the representative of cash. Nor is our paper equally stable with the British in respect of the following circumstances. 1st. The real actual wealth, upon which the personal credit of that country is founded, is more marketable, than ours: owing to the greater facility of sales from the greater riches of that country. 2ly. Accommodation notes are greatly discountenanced there. 3ly. Every bank, but the bank of England, is founded, not on the limited security of the amount of joint stock, but upon the known character and solvency of the individual partners who compose the firm. Our unlimited issues of paper currency, must ultimately tend to drive away all coin, to raise the paper price of every commodity, to encrease the number of forgeries and the difficulty of detection, and ultimately to sink the value of the paper itself. Banks are now founded, not on the necessities of the country, but of the speculators who set them up. In the end, the evil will cure itself; but it will be severely felt.

The advocates of banks, say, wherever a bank is established, land encreases in value, all kinds of property advance. It is not so; no value is added to land, but the value of paper money is lessened, as is the case with every commodity wherewith the market is overstocked. So far as banks give a temporary facility to public enterprizes, they are of use: they are of great use also in checking the monopolies of monied men, and equalizing, in some degree, purchasers in the commercial markets: but these benefits are greatly overbalanced by the evils arising from their unlimited extension. They banish the precious metals; they tend to check exportation by raising the nominal price of commodities; they encourage irregular trade on fictitious capital; they promote wild speculation; and they strongly tempt to unwarrantable expence and extravagance in the manner of living. In this country, the many kinds of bank paper, will soon make it hazardous to take any; for by and by we shall have no means of detecting the spurious notes. The British government transmitted to France immense quantities of forged assignats. The for-

geries of American papers have been a trade in London;* need we be surprised if we should be inundated with forged notes?

A national bank in this country, would be an excellent establishment, if well planned and conducted; but the constitutional

* *Simulated Papers.*—It is an undeniable fact that the greater part of the difficulties our commerce has felt from the continental powers of Europe have had their origin in the frauds and forgeries of the *British.* Protected by the cannon of their navy, five thousand voyages have been annually made with ships bearing the *American* flag, and completely provided with *counterfeited papers,* which may be purchased in *London* and elsewhere as unceremoniously as a *package of pins.* The vessels thus furnished, and in many instances laden with the productions of the United States, are safely convoyed to the neighbourhood of places to which a simple clearance, from a real American custom-house, would render the vessel liable to seizure and condemnation, the moment she left the waters of the United States! Here is the operation of the *orders in council.* Englishmen in America begin to blush at the outrageous falsehoods they told in maintaining that these orders were *intended to retaliate* on the Berlin and Milan decrees.—They were originally designed for the simple object of destroying the trade of the United States; or, more extensively speaking, of forcing the commerce of the world through *British* ports.

The manufacture of simulated papers has become a regular business in England. The *workmen,* like *other mechanics,* publicly recommend themselves to notice for their great experience, &c. and in this they are countenanced by the ministry.

In the course of his late speech in parliament, Mr. *Brougham* read the following circular letter from a "*house*" in Liverpool, announcing that the persons by whom it was subscribed, after labouring some time as apprentices, and being well versed in the craft, had commenced as masters for themselves:— *(2 Miles's Reg. 166.)*

"Liverpool, ———.

"*Gentlemen*—We take the liberty herewith to inform you, that we have established ourselves in this town for the purpose of making simulated papers—*(Hear! hear!)*—which we are enabled to do in a way which will give ample satisfaction to our employers, not only being in possession of the original documents of the ships' papers, and clearances to various ports, a list of which we annex; but our Mr. G— B— having worked with his brother, Mr. J— B—, in the same line, for the last two years, and understanding all the necessary languages.

"Of any changes that may occur in the different places on the continent, we are careful to have the earliest information, not only from our own connections, but from Mr. J— B—, who has proffered his assistance in every way, and who has for some time past made simulated papers for Messrs. B— and P—, of this town, to whom we beg leave to refer you for further information. We remain, &c. Then follows a list of about twenty places, from and to which they can forge papers, having all the clearances ready by them, from the different public agents, the moment they receive intelligence that any merchant may need their assistance in this scheme of fabrication."

objection to it is so strong, that it ought to be fairly gotten rid of, by an amendment to the constitution in the first instance.

I may probably take up this question again in a future number, when I arrive at the banking part of the United States' statistics. The circulation of Bank of England paper in that country, has already been given.

In noticing this matter Mr. *Stephens* said, "he would ask gentlemen *sincerely* were they prepared to abandon all trade to the continent of Europe on account of these objections *in point of morality*, which had been stated by the hon. mover? [Mr. Brougham.] He felt himself perfectly ready to meet any gentleman upon this ground; and he really believed that he would find few who had *weakness* enough to think, or *hypocrisy* enough to assert, that the whole trade of Europe ought to be abandoned on account of the immorality of FRAUDS *necessarily* practised in the carrying it on. As to the *forging* papers and French consuls' certificates of origin, he was convinced that neither this, nor shewing *false colours* to the enemy, would be supposed so serious an immorality as to make us consent to abandon all our trade." Mr. *Stephens* is the author of the pamphlet entitled '*war in disguise*—or the *frauds of neutral flags!*'

British Manufactures.—To such *manufactures* as are publicly and unblushingly offered for sale in the following advertisement, copied from the *London* Morning Chronicle, of June 12, 1812, we are indebted for a great part of the losses, privations and perplexities suffered on the European continent for many years past. We record the whole notice as a curious article. 3 *Niles*, 63.

"To ship brokers, custom-house agents, notaries public, merchants, &c. Simulated papers and seals, capital counting-house fixtures, 20 very excellent and expensive charts and maps, &c.—By Mr. Sampson, at his warehouse, 16, Size-lane, Bucklersbury, on Thursday next, at 11, by direction of the assignees.

The valuable fixtures and fittings up of the counting-houses, 34 boxes containing *simulated ships' papers and seals for foreign countries*, various coloured Inks, foreign writing paper, &c. of Mr. Peter Vander, A. A. merchant, a bankrupt, (removed from his offices, No. 9, Water-lane, Tower-st.) comprising 7 mahogany 1 flap and 2 flap counting-house desks, book case, two capital library and writing tables, with drawers, stamping and sealing presses, a patent instantaneous light machine, an excellent mahogany portable writing desk with secret drawers, two patent polygraphs, several capital charts, amongst which are the Northern Sea, the Cattegat, the Azores, the Atlantic Ocean, the Baltic Pilot, West Indies, British Channel, coasts of England and Holland, Mediterranean, Europe, Asia, and America; Mercator's World; Laurie and Whittle's new map of the British Isles, on spring rollers and boxes: Carey's universal Atlas; a new ledger, journal and waste books, 5 vols. of the beauties of England and Wales, and 95 numbers of do. 6 morrocco leather cases, &c. To be viewed two days preceding the sale, at the broker's warehouses; catalogues may be had of Messrs. Sweet and Stokes, solicitors, Basinghall street, and of Mr. Sampson, 16, Size-lane, Bucklersbury."

TO READERS:—VARIOUS NOTICES.

I have been in Philadelphia for a short time, during the printing of this number: hence some inaccuracies of printing, and of arrangement have taken place in the present number. Among others, I wish the reader to correct in p. 169, line 9 from the bottom, as follows: for *which*, read, *to which*. In p. 172, the account of the accident from the blowing up of Mr. Trevethick's engine, is from the Philos. Magazine. The account of Mr. Nancarrow's engine, is copied by Nicholson in his 4th quarto volume of his Journal, from the transactions of the American Philosophical society. In p. 218, line 12 from the top, for *upwright*, read, *upright*, and for *presents*, read, *preserves*. In p. 219, line 3 from the bottom, for *using as the metalline substances*, read, *using metalline substances*. Some of my finance collections are not exactly arranged as I could wish, but I do not observe any material error.

While in Philadelphia, I went from thence to Germantown to look at an engine of Messrs. Lang and Hauto, constructed with a view to economise the force of water, and use streams too small to be employed in the common methods of water wheels. The engine in question, is constructed on the principle of the hydrostatical paradox, namely, that the force of pressure of water, depends not upon the quantity, but on the height of the column. Mr. Brama, in London, took out a patent some years ago for a packing-engine, constructed on this principle, to which also he applied a forcing engine in addition to the height of the column. In the principle, therefore, there does not appear to me any thing new: but in the application of this engine to communicate rotatory motion, I think there is great merit. I do not say that this part of the machinery is absolutely new, but it is so to me. I shall give a description of this engine, which ought to be known; for the principle is capable of converting every house in Front and Water streets in Philadelphia, into a manufactory, by the application of the water from the reservoir of the water works.

Sugar.—During the late dearness of sugar, Mr. Patterson, and my friend Mr. Cloud, of the mint, repeated the experiment mentioned in one of my late Emporiums, on the conversion of Starch into sugar, with success as to the general result, but not as to the cheapness. Oil of vitriol is greatly too dear in this country; in England it sells wholesale for 3½ pence sterling per lb;

the saleable weight is, that a wine pint by measure shall weigh 29¼ ounces.

They then tried an evaporated decoction of malt. By making a wort, or simple decoction of malt (the malt should be put in cold w ater, and gradually heated, for boiling water sets it, as the term is, T. C.) and evaporating this to the consistence of common molasses, they produced a species of molasses sufficiently similar to the common article, and sweet enough to be used with coffee, at an expence of materials that would amount to about thirty-five cents per gallon. This experiment deserves to be repeated in every family.

I do not give Mr. Cloud's method of making Seltzer water, or his method of procuring Zinc from the common brown and black blende, because I hope he will give these processes himself.

Gunpowder.—I observe in the papers the following advertisement. I know nothing of the improvements suggested, but from the advertisement itself; and I have no knowledge whatever of the advertiser. I copy it, as notice of the application of steam to the manufacture of gunpowder, which I believe to be practicable, and also to be a real improvement. Whether it be adopted in England or not, or whether among the numerous patents granted for the application of steam to the arts and manufactures of that country, any patent has been taken out for its application to gunpowder, I know not. I wish somebody would publish a list of patents taken out in that country and in this, from the date of the first vol. of the Repertory of Arts, in 1794, to the present time. I have not the command of more than 20 volumes. I have no doubt but very many of our home-bred patents would be found in the English collection. I will take an opportunity, ere long, of giving my opinion on patent rights. But I have at present no intention of applying this remark to the subsequent advertisement, for I know not the process. Steam has long been applied in England to the warming of buildings, to medicinal baths, to the heating of boilers, to dying, to bleaching, to soap-boiling, to distilling, to the heating of drying-houses, as malt-floors, &c. &c. and also to the drying of gunpowder. Mr. Woolf in the description of his boiler, which I shall give in my next, expressly notices the application of steam to the gunpowder manufacture; and it is stated as being generally introduced, in the article *gunpowder*, Rees's Encyclopedia. However, as it is certainly a very feasible, and very important improvement, I give place to the following advertisement.

" *To Powder Manufacturers.*—The subscriber has obtained from the United States a patent right, for three very simple and important improvements in the manufacture of gunpowder, which do most truly diminish more than one half the risk, the waste, and the expence of the manufacture. They consist in boiling the ingredients by steam, in incorporating them without the objection of barrels, the danger of pounders, or the tediousness of stones running on their edge: and in the granulations effected by a simple machine turning by hand or water, and graining more in a day than twenty hands, losing not a particle of dust, and making not half the ordinary quantity for re-manufacture. The advantages of this mode have been so great, that he had to discharge half of his workmen from his manufactory, as will be readily accounted for by those accustomed to the tediousness and loss from graining, particularly the press powder by the sifter and rollers.

The terms on which he will dispose of his improvements are as follows:

For the privilege of using the steam and his wheel for incorporation, which he will supply, and have put up in any part of the country at his own expence, within 60 days from the arrival of his workmen, one thousand dollars for each hundred pounds of powder they are able to manufacture daily. None less than three hundred pounds will be undertaken.

For his granulating machines, also made and put up at his own expence, he will charge and must be secured in the payment of so much as the manufacturer shall save, by discontinuing the operations of the sifter for the first year, one half for the second, and one fourth for the third, and the same for the fourth years, to be paid at the expiration of the years, after which no further charge. This amount is to be ascertained on the fairest principles in the beginning, and nothing is to be paid if the machine do not fully answer the object. It is of so simple a nature, so impossible to get out of order, or under any circumstances to be a source of danger, that should any person wish it he will for the first year have one of his hands to grain, and will guarantee all losses that it shall from its operations produce, no one, however, will require this, who will observe the perfect safety and simplicity of the contrivance.

The established manufacturers wishing only the granulating machine, will state (letters postage paid) the quantity of powder they daily make, and immediately after they shall have one of corresponding capacity put in operation free of all expences, but the allowance for saving, to be paid for as above."

Georgetown, December 30. THOMAS EWELL.

Steam Engine applied to Weaving.—Towards the close of the session of parliament, in 1809, a motion was put and agreed to, for granting 10,000*l.* to Dr. Edward Cartwright, for applying the use of steam engines to the working of looms. It appeared from the report of Mr. Banks, the chairman of the committee, that although this gentleman made a very useful discovery, and for which he obtained his majesty's letters patent, it was not for that alone he obtained remuneration, but that in the year 1792, the weavers at Manchester, rose and destroyed all his apparatus; in consequence of which it was alleged, the government was deficient in protecting his property, and for this the sum was granted. It appeared also, from the report of the committee on the case, that great advantage had arisen from the invention, and that the Dr. had expended 30,000*l.* in bringing it to perfection.

Filtered Aquaducts.—The corporation of Philadelphia, I observe, are making a Reservoir above the Upper Ferry. The great objection to the hydrant water, is its muddiness. I recommend to public notice the following account, which ought at least to stimulate the directors of the Philadelphia reservoir, to adopt this very simple, but prodigious improvement in the wholesomeness, and pleasantness of our most necessary beverage. I fear, however, I shall preach in vain. For ten years last past, I have occasionally written against the nuisance of a smoking fire place to a steam engine, but without effect. Doubtless they are proper subjects of indictment, but no one cares how much fire and smoke the monsters pour forth open mouthed, over the devoted city. Nothing would give me greater pleasure than to hear of a dozen or twenty new steam engines in Philadelphia, for manufactures will never flourish as they ought, till steam engines are common. I hope too they will all smoke lustily, till the nuisance be really felt.

"An abundant supply of good water is one of the most indispensable requisites for the cleanliness and health of the inhabitants of our large manufacturing towns in particular; and although improvements have been made in this respect, more or less, throughout the United Kingdom, yet much more still remains to be done, and the attention of the public at large should be called to this very essential point.

"Till lately, collections of spring water have been preferred for the purpose of supplying towns by means of pipes, from its supposed greater purity; but experience and the progress of science have proved that spring water is far inferior to river water for this

purpose: river water contains impurities visible to the eye; spring water contains them in a state of actual solution, and therefore invisible. From the former, the impurities will separate themselves almost entirely, by rest or by filtration; from the latter they cannot be separated by means adapted to the demands of common life.

"London, which is extremely healthy for its size, has long been supplied with river water, and to this, more than to any other circumstances, are the inhabitants indebted for the health they enjoy, though few of them ever take the trouble to filter the water they use, even for culinary purposes. The city of Glasgow, which till lately had no supply of water but from wells, has at length the prospect of an inexhaustible supply from the river Clyde, by means of pipes and steam engines. Two companies have embarked in similar undertakings; one of them under the direction of Mr. Thomas Telford, civil engineer, undertakes to bring in a large supply from the eastward of the town; the other company, under the direction of Mr. Robertson Buchanan, to bring in a similar supply from the westward. Both works are in considerable forwardness, and many houses are already supplied with pipes; but the circumstance which demands most attention from the public, and which is our principal reason of mentioning these undertakings, is *the filtration of the whole supply of water, by means of reservoirs constructed for that purpose.* This salutary process is effected by making the water filter through sand and gravel from the large reservoir into which it is first elevated by the steam engine, into a second reservoir deposited a little lower, and from which the conveying pipes receive their supply.

"This is the first instance, we believe (and well deserving imitation), that has as yet occurred of water being filtered on so large a scale, and when its advantages, not only to the health of the inhabitants, but to bleachers, dyers, and all other manufacturers, are duly considered, we cannot doubt but that it will be adopted in all future undertakings for supplying towns with water. Hitherto all branches of manufacture connected with the use of water have been obliged to be *carried to the water*, and the necessary hands along with them, and much expence for carriage and extra labour has been added to the price; but should this system become general, manufactures will be carried on where the necessary supply of labourers can be most easily procured, and where the goods so manufactured can find the most ready market.

"We believe that the filtration of water intended for public sup-

ply was first practised by a private individual at Paisley. This public spirited adventurer was amply remunerated for his expenditure, and we cannot doubt but that similar speculations on a larger scale, if properly conducted, will yield an ample return to the first subscribers. We hope the example which has thus been given will be followed by public spirited individuals in other large towns. Its benefits would soon be felt, and it would yield advantages to the community in general, which cannot be calculated upon." (4 *Comm. Mag*. 121.)

Sheet Iron. Ordnance. Iron Cables.—In consequence of information requested of me, I have found it necessary to make some enquiries, as to the manufacture of *Sheet Iron.* The fault of this article when made in this country, is stated to be, that the plates, or sheets, are rough and uneven in consequence of the scales they acquire in the process of heating for the purpose of being rolled. The appearance of the plates is mended, by being annealed or slightly blued, but this is no cure for the evil. My notions on the subject are these.

Every metal, particularly Iron, when exposed to atmospheric air in a red heat, will attract and combine with the oxygen of the atmosphere, and become oxyded. The oxyded iron will either scale off, or remain upon the plate in the form of scales, and make it rough. The cause of the scales and of the roughness of the surface, therefore, is oxyded iron. The cause of the iron becoming oxyded, is that a current of air, not deprived of its oxygen by the coals, comes in contact with the hot iron, and deposits its unconsumed oxygen in the metal.

When a plate of iron is laid upon charcoal for the purpose of being heated previous to its being rolled, the interstices of the charcoal admit more air than the charcoal can consume, or de-oxygenate: that air combines with the under side of the plate, which thereby becomes rough and scaly: the upper side of the plate becomes less so, because the air that passes over it is in part deprived of its oxygen. If there be three plates, the bottom of the undermost will be most oxyded, and then the top of the uppermost. The middle plate will be free from scales: it is heated in the same manner as if it were in a muffle, which is the method of heating the iron intended to be rolled, in some parts of England, and effectually prevents the imperfection complained of.

If, instead of charcoal, a bituminous stone coal is used, the iron plate comes away from the fire much purer and cleaner. The

coals are apt to coak together, and admit no more air through them, than they can decompose: besides which, the smoke of the coal greatly tends to decompose the current of air which passes immediately under the lowest plate. Coal, therefore, is the best fuel for the purpose; that is, the coal that smokes and flames, while it burns.

But, *if the rollers be well greased* while the iron is passing through them, which they ought to be, the scales separate, the surface becomes smooth, and a fine bluish colour can be afterward given by proper annealing, if it be necessary to please the eyesight.

While I am upon the subject of iron, I feel much inclined to regret that the Ordnance with which our Navy is supplied, is not better than I hear it is. I do not know the fact, but I am told, that had the guns on board Commodore Rogers's ship been good, he would have taken the Little Belt: and that Commodore Chauncey was nearly killed by the bursting of a cannon; an accident that happens so frequently on board our vessels of war, as to become an evil of great magnitude. About a month ago a general officer in our regular army, told me, that he had seen a lump of lead about five pounds weight taken out of a cannon; the lead had been run in to conceal a defect in the casting. If this be the case, some remedy should be applied.

In England, spring-chains of iron have been substituted instead of *Cables*. In 1812 three ships of the line were thus fitted up: whether the improvement, if it be one, is continued, I know not.

Thermometers.—The following formulæ for the conversion of the degrees of the various Thermometers that are in use in this country, in England, and the continent of Europe, into each other, will be found useful to a chemical and philosophical student.

To convert the degrees of Reamur's into those of Fahrenheit's. $\frac{R\times9}{4}+32=F$. 2d. To convert those of Fahrenheit into Reamur's. $\frac{F-32\times4}{9}=R$. 3d. To convert Celsius's into Fah. $\frac{C\times9}{5}+32=F$. 4th. To convert Fahrenheit's into Celsius's. $\frac{F-32\times5}{9}=C$. 5th. To convert Celsius's degrees into Reamur's $\frac{C\times4}{5}=R$. 6th. To convert Reamur's into Celsius's. $\frac{R\times5}{4}=C$.

Thus we may convert the one into the other with the greatest facility, but to such readers as are unacquainted with the algebraic expressions of arithmetical formulæ, it will be necessary to express one or two of them in words, in order that their use may be understood. First, then, To convert the degrees of Reamur's into those of Fahrenheit's: Multiply the degree of Reamur by 9, divide the product by 4, and to the quotient add 32; the sum expresses the corresponding degree on the scale of Fahrenheit. Second, To convert the degrees of Fahrenheit into those of Reamur: From the degrees of Fahrenheit subtract 32, multiply the remainder by 4, and divide the product by 9, the quotient will be the degree according to the scale of Reamur. And so on for the rest.

Poppy Oil. Benni Seed. Ben Nut. At Harmony, half a day's ride from Pittsburgh, (both places objects of very great interest) the settlers, use oil expressed from the poppy seed, exclusively, in lieu of olive oil for sallads, &c. It is nearly, if not quite equally good. This oil is becoming common in Europe as a substitute for olive oil. The poppy seed, may be eaten with impunity when ripe. I do not see why its use should be confined to the settlement of Harmony. The Ben, Bene, or Benni Seed common in the Carolinas, can furnish, as I am informed, oil enough to supply the United States at a cheap rate. I have eaten the oil of the Ben or Behen nut in England, and I find no difference between it, and olive oil. Why should this last be imported? But I doubt whether the Ben or Behen nut be the same with the Benni seed. I suspect this last to be the *Sesamum;* but I have never seen it. The Behen nut, *Glans unguentarius*, *Balenos murepsiki*, is the fruit of the *Guilandina Moringa.* The oil is prepared in the Levant, in Egypt, in Syria, and in Italy, by expression. It is valuable for its purity, and its freedom from smell and taste, and for its property of remaining long without alteration or rancidity, which makes it extremely valuable in pharmaceutical preparations. Rees' Encyclopædia.

Madder.—A few years ago, I procured from England, and I distributed in Philadelphia some plants of the Smyrna Madder (*Lizari*) to Mr. Bern. M'Mahon, to Mr. J. Vaughan, to Mr. Jos. Clay, to Mr. Seth Craig. I know not what has been done with them, or whether any of the plants lived. I do not know a more valuable present that could be made to the cotton manufacture of this country. The Turkey red cannot be well dyed with the Dutch, Zealand, or Crop Madder. I mention this in consequence of knowing that the Harmony settlers, raise all their own madder, for

their extensive woollen manufactory, why cannot this be done every where?

English Madder.—Mr. Spencer Smith has lately introduced that valuable plant, Smyrna Madder, into this country. Mr. Smith furnished the society of Arts with some seed, from which Mr. Salisbury, of the Botanical-garden, Sloane-street, has raised plants that have grown in the most promising manner; he expects to obtain seed from them, and there is every reason to hope that this useful dye-root will, in a short time, become naturalized to our soil. (3 *Comm. Mag.* 248.)

Query on the Cultivation of Madder, and Observations thereon.

To the Editor of the Tradesman, or Commercial Magazine.

SIR,—In looking over the list of articles permitted to be imported to this country from the enemy under his majesty's Orders in Council, and for which it should appear that we stand in great need for the support of our manufactures, I observe the article of madder one, and on referring to the custom house lists of importation, I see that article makes a very conspicuous figure against our balance of trade. As this is an article mostly brought from Holland, it may be inferred that the climate of England would not be unfavourable thereto; and although the great argument is for cultivating every possible spot with the more necessary article of corn, yet there are many unprofitable and considerable spots of ground unoccupied, quite unfavourable to wheat or other corn, that I may presume might be occupied by the cultivation of madder; I could therefore wish to know if it has been attempted, and with success in this country. If trial has not already been made, it is not too late to attempt it, and at the same time I beg leave to close my question with the following account of the cultivation of that root, for the benefit of those whom it may concern, taken from the French Journal de Physique.

This plant may be propagated either by offsets or seeds; if the latter method is preferred, the seed should be of the true Turkish kind, which is called *lizari* in the Levant. On a light thin soil the culture cannot be carried on to any degree of profit, that soil in which the plant delights is a rich sandy loam, being three feet or more in depth. The ground being first made smooth is divided into beds four feet wide, with alternate alleys, half as broad again as the beds; the reason of this extraordinary breadth of the alleys will appear presently. In each alley is to be a shallow channel for the convenience of irrigating the whole field, &c.;

that part of the alley which is not otherwise occupied may be sown with legumes.

"The madder seed is sown broad cast in the proportion of from 25 lbs. to 30 lbs. per acre, about the end of April. In a fortnight or three weeks the young plants begin to appear, and from this time to the month of September, care must be taken to keep the ground well watered and free from weeds; if the plants are examined in autumn they will be found surrounded with small yellow offsets, at the depth of two inches; and early in September the earth from the alleys is to be dug out, and laid over the plants of madder to the heights of two or three feet, with this the first year's operation finishes. The second year's work begins in May, with giving the beds a thorough weeding, and care must be taken to supply them with plenty of water during the summer; in September the first crop of seed will be ripe, at which time the stems of the plants may be mown down, and the roots covered a few inches with earth taken as before out of the alleys. The weeding should take place as early as possible in the spring of the third year, and the crop, instead of being left for seed, may be cut three times during summer for green fodder, all kinds of cattle being remarkably fond of it. In October the roots are taken up, the offsets carefully separated and immediately used to form a new plantation, and the roots, after being dried, are sold, either without further preparation, or ground to a coarse powder and sprinkled with an alkaline ley. The roots lose four-fifths of their weight in drying, and the produce of an acre is about two thousand pounds weight of dry saleable madder.

"I need not take up more of your time or place by pointing out the variety of uses this root is of, particularly in various colours for dying, nor pointing out the profit to be derived from a cultivation of this root, an acre producing a ton, saleable at more than 120*l*.; but this would depend upon circumstances and the success of the cultivation.

Your's truly,

K. K.

Manchester, February, 1810.

"Respecting the subject of cultivating Madder in this country, we beg leave to inform our Correspondent, that it has already been attempted, but of the particulars attending it, or probable result, we are not yet so fully acquainted as to be sanguine in expectation of the result thereof: in page 248, No. 15, Vol. 3. will be seen a no-

tice of the cultivation of Smyrna Madder in this country, by Mr. Spencer Smith; and also that the seeds had propagated the plant with *experimental success*, in the Botanical Garden at Sloane-street. —*Editor of Com. Mag.*"

For further information as to the method of cultivating madder, I refer to Arthur Young's account of Mr. Arbuthnot's madder plantation, and (not the article madder alone but) to the articles *madder*, in Rees's Encyclopædia, particularly the last article entitled Madder, Rubia tinctorum. They are neither of them very good, but I know no better. I will send to Harmony for the practice there.

In England, the whole supply of *weld* for the finer tints of permanent yellow, is from Yorkshire. *Weld* gives a brighter colour than the inner bark of the black-oak, or Quercetron of Dr. Bancroft. Can there be any difficulty whatever in growing Weld here?

T. C.

" *Wines of Spain and Portugal.*—The wines of Spain are of two descriptions, namely, white and red, and are, for the most part, excellent. The greatest quantity of wine is made in the southern parts of the kingdom, and the sale of the article is very extensive, especially among the English and the Dutch. The wines of the Canaries, although not of actual Spanish growth, are to be met with in most of the ports of Spain, and are usually classed with the wines of that country. Although the whole of the Canaries produce excellent wines, the preference is given to those of Palma and Teneriffe. The Dutch and the English, carry on the most extensive traffic in the wines of these two islands, the latter annually taking off no less than 16,000 tons of wine; part of which they destine for the northern ports and part for England. Many other nations are engaged in an inferior degree in this traffic. When the vintage proves favourable, Teneriffe annually makes up about 30,000 pipes of Vidonia, or, as it is sometimes denominated, *Bastard Madeira*, from the similarity of its flavour and appearance to the dry wine of the last mentioned island. Teneriffe also produces a sweet wine, which comes very near Malmsey Madeira: this is sold in the island at about 14*l.* though sometimes as high as 20*l.* per pipe, and the Vidonia at 10*l.* and upwards. The duty paid at the port of London on Teneriffe wines is 107*l.* 11*s.* per ton, and the market price of Vidonia at present (duty included) is from 70*l.* to 85*l.* per pipe, (1808).

" The wine of Chacoli, in Biscay, is not of a first rate quality. In order to produce this wine the Biscayans ingraft five or six

different vines upon the same stalk. Most parts of Biscay abound in these vines, which border the high roads, generally growing to the height of about three or four feet. The wine in Biscay is sold at a certain price, as regulated by the police, and until the whole produce of the vintage is disposed of, no foreign wine is permitted to be brought into the province; hence it happens that the sole study of the proprietors of vineyards is to collect a large quantity of wine, without attending to quality or flavour, and consequently Chacoli has become proverbially despicable in Spain. Indeed the grapes are not allowed to arrive at a state of maturity, but are gathered and squeezed, while sour and nearly devoid of substance; now if the juice were allowed to collect and meliorate in the grape, if the green fruit were not mingled with the ripe, if the wines were made with the same care as are those of other provinces, this *despicable* Chacoli would undergo a proper fermentation, gain strength, acquire a delicious flavour in lieu of its present acid and nauseous taste, and would moreover prove equal in every respect (except that of seniority) to the French Champaign, which, of its kind, stands at present unrivalled.

"The wine of Guidas, in Castile, is made from cherries, and is a species of Ratifia. Foucal wine, which takes its name from a village situate near Madrid, is of a good quality, but it is only reckoned an ordinary wine.

"The wines of Val de Penas, Ciudad Real, Ribadavia, and Rioxa, and those called La Mancha are very good, and except in regard to different degrees of colour, are nearly similar in every respect.

"The best wines of Arragon are those denominated Garnachas, so called from the species of grape which produces them: the best of all is a red wine named Hospital; it is excellent as to flavour, strength, &c. and is besides a capital stomachic. Caninea, called likewise white Garnachas, is very fine, and is much esteemed.

"The wines of Peralta, Tudela, Tafalla, and Arandillo in Navarre, are nearly alike, and are excellent both as to flavour and quality. That of Peralta is well known under the title of Rancio, which it receives when old enough to merit that distinction. To these may be added the wine of Iluesca, which is very good.

"The wines of Xeres, better known under the name of Sherry, are made at the aforesaid town, which is situated in the province of Andalusia. They are not only dry but sweet; the dry, however, are the most esteemed, more particularly when their face

presents a pale straw colour. Many who are in the habit of tasting Sherry, have doubtless perceived that there is something in its flavour which partakes of the taste of leather; this is owing to the custom of bringing the wines down the country in large leathern vessels, or, as the Spaniards call them, *boots*, whence we derive our term butts, which we bestow upon the casks wherein we receive the wines. These wines are shipped at most of the Spanish ports, but particularly at Cadiz, for all parts of Europe, but indubitably the greatest quantity is sent to England. The present prices of Sherry are from 80*l.* to 100 guineas per butt.

"In Andalusia are also made sweet and dry wines called Pagarete* and San Lucar, and the strong well known red wine, denominated Tinto Rota or Tent, which is an excellent stomachic, and is generally recommended by skilful *accoucheurs*, as being of infinite service to women in child-bed. The Montilla is a dry wine. The territory of Xeres alone annually produces above 60,000 pipes of wine.

"In the province of Grenada, is made the celebrated wine called Mountain or Malaga, which is commonly shipped from the port of Malaga. Vast quantities are exported for England and Ireland. It is dry and sweet, and is both red and white. It is a truly delicious wine, and is much esteemed in Great Britain; its prices in the English market, at present, vary from 60*l.* to 80*l.* The sweet Mountain is the most sought after, and is usually employed as a desert wine. Grenada produces Peroximenes or Pedro Ximenes,† which is oftener imported into Ireland than England; it is a very fine flavoured full bodied wine. There is also a kind of Malmsey made in this province, which is exquisite; but that of Maravella is only an ordinary wine.

"In Valentia is found Tinto Alicante, a wine much used in France; it is sweet when new, but grows thick and ropy as it becomes aged: it is a good stomachic.

"The Benicarlo wine is red, dry, and thick; it is often palmed upon the public by wine dealers as Port wine, to which it is very inferior both in quality and price. An imposition of this sort is to be avoided by observing whether the wine offered have a ruby colour instead of a deep black, a generous flavour, and not that harshness which immediately offends a good palate; if not, it assuredly cannot be Port wine. The wine called Siches and that called G rnache, both made in Catalonia, are exquisite. In the same province are made Tinto de las Montanas or Mountain Tent, and

* Pachioretti. † Padre Ximenes.

Mataro wine, both of which are sweet, thick, ropy, and unwholesome.* The latter is often sold by irreputable traders to private families as Tent, but in this respect an experienced wine broker cannot be deceived.

" It is almost needless to observe that the wine called Port, of which such vast quantities are consumed in Great Britain, is the produce of Portugal. The vines, whence it is made, grow upon the banks of the Douro, about 14 or 15 leagues from Oporto, and occupy a space about six leagues in length, and two leagues in breadth. These vineyards produce between 60 and 70,000 pipes of Port, and there are others which yield nearly 6,000 pipes annually. The vine whence we derive our Port, originally grew in Burgundy, but the climate of Portugal, being widely different from that of Burgundy, has caused such an alteration in the grape, that no two wines are more unlike than those which are the produce of each of the above mentioned territories. The wines Di Ranio* are prohibited from being exported to any part of the world except Brazil, but the English factory established at Oporto have sometimes contrived to ship a few pipes to this country.

" In the province of Algarva a small quantity of indifferent wine is made, but it constitutes no branch of export trade; indeed Port is the only wine which the Portuguese derive profit from, and it may be truly said to be the grand prop of their commerce. The wines of Portugal, like those of Biscay, are only sold at the prices annually regulated by the government. As soon as the prices are promulgated, the factory and individuals send in their names to the proprietors of the wines; the whole of the Port wine is shipped at Oporto.

" The brandy of Spain constitutes an article of considerable commerce; it is very inferior to the brandy of France, and is principally used in making up Spanish and Portuguese wines. The brandy of Portugal is nearly the same as that of Spain, very little of it is exported.

" Raisins or dried grapes are produced in abundance in all the provinces of Spain. The Valentia and Grenada raisins are certainly the most esteemed of any, the produce of Spain. The mode of drying grapes at Valentia is as follows: The grapes are first dried in a ley made of vine stalks, the juice issues from the pores of the fruit, and when placed in the open air is crystallised; the raisins

* A light Port.

are finally exposed to the sun, after which nothing can improve them more than a voyage.

"Immense quantities of most excellent barilla, pot-ash, and pearl-ash, chiefly the produce of Alicant, Valentia, Murcia, and part of Grenada, are annually exported from Spain; there is no country in the world whence these articles are to be met with in greater perfection than in this.

"The oranges and lemons of Spain are of a very excellent kind, and large quantities are annually exported from the different ports of that country for England and Ireland; from September till January is the properest time for shipping these fruits; it is dangerous to speculate in the articles at other seasons.

"Spain likewise produces some oil, which is seldom exported, and is often used as a substitute for butter; hemp, which is grown in Grenada, Murcia, and Valentia; senna, which has been preferred to that of the Levant; tobacco of the finest quality; and wool, whose excellent quality is too well known to need any comment.

"The fruits of Portugal, which are esteemed by foreigners, consist of figs, grown in the kingdom of Algarva exclusively, and which are said to be superior to those of Spain and Barbary; almonds far inferior to those of Spain (which are indeed excellent, especially such as are shipped from Valentia); oranges and lemons, more noted for their quantity than their quality; and some wools."

Alexander & Phillips, Printers, Carlisle.

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CONTENTS.

ERRATUM.

In page 300 under Poor, for *duennially* read *decennially*

THE

EMPORIUM

OF

ARTS AND SCIENCES.

VOL. II.

(*NEW SERIES.*)

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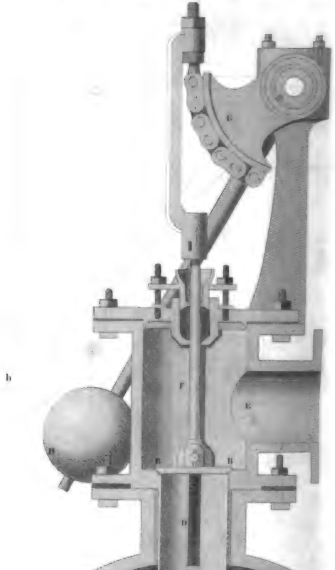
Self acting & regulating Steam Valve by Mr. Arthur Woolf.



THE

EMPORIUM

OF

ARTS AND SCIENCES.

VOL. II. APRIL, 1814. No. III.

STEAM ENGINE.

(Concluded.)

I HAVE not procured the specification of which the following is an extract. I copy the Monthly Magazine for October, 1811, vol. 32, p. 255.

Mr. Arthur Woolf's Patent, for improvements in the construction and working of Steam Engines, calculated to lessen the consumption of fuel.

THE nature of this invention may be thus described: The working cylinder of the steam engine has no bottom, but is enclosed in another cylinder of such dimensions, that the space between the two, which space is called the receiver, is equal to at least the contents of the working cylinder. The enclosing cylinder has a bottom, and the two cylinders are joined together at the top by flanghes, or any other suitable means, and the lower rim of the working cylinder is about as far distant from the inclosing cylinder as the distance between the sides of the two cylinders. Instead of having a void space for receiving

steam below the piston, Mr. W. introduces below it, and into the receiver, such a quantity of oil, &c. as shall, when the piston is at its greatest height, in the working cylinder, fill all the space below it, and fill also the receiver up to the height of a few inches above the lower rim of the working cylinder. If the engine is to be worked by the pressure of the atmosphere, the receiver has a communication with the boiler, which communication being opened, steam is admitted into, and fills the receiver above the oil. If the communication between the receiver and the boiler be now shut off, and a communication be opened from the receiver to the condenser, a vacuum will be formed in the receiver, and then the pressure of the atmosphere, acting upon the piston, will cause it to descend in the working cylinder, pressing the oil, or other fluid body, before it, and causing the fluid to ascend into the receiver; after which the steam is again admitted for the next stroke. If the engine is to be worked by the action of the steam upon the piston, then the working cylinder must, as is usual in steam engines so worked, be furnished with a cover. In this case, instead of the communication usual in the engines in common use, for the alternate admission and condensation of steam above and below the piston, the communications in this engine are to the upper part of the working cylinder, and to the upper part of the receivers, the receiver in the engine answering to the space below the piston in other steam engines; so that, when the receiver is open to the condenser, and the upper part of the working cylinder open to the boiler, the piston ascends, and vice versâ. To prevent waste of steam, and to keep up the temperature of the oil, the receiver may be enclosed in a steam case, or heat may be applied externally. There should always be some oil above the piston to the height of a few inches, to prevent the passage of the atmospheric air, or of the steam, down-

wards, by the side of the piston. To prevent any deviation of the quantity of oil by the working of the engine, means must be provided to restore it to the requisite height, as cocks, valves, &c. regulated by a float or floats upon the surface of the oil, or by means of a pump or pumps worked by the engine itself, or otherwise. By the interposition of the oil, between the piston and the condenser, all waste of steam, by passing the piston, is effectually prevented, and a consequent saving of fuel is effected.

Woolf's method of measuring the elastic force of Steam.

PLATE I. of this number exhibits a measured section of the self-acting and regulating steam valve. A A represents the upper part of the boiler, having its mouth or neck cylindrical, and closed by a well-fitted, but easily moving valve plug, B B C C, which is in fact a metallic tube, open at bottom and closed above, by a cap-piece B B, that by its chamfered rim or projecting part affords the accurate valve-closure when down. The interior parallel lines at D shew the place where a long perforation is made through the side of the cylindrical part of the valve plug from its cap, nearly down to the bottom; which perforation affords a passage for the steam, increasing in magnitude as the elastic force causes the valve to rise. E is the side passage for conveying the steam to its place of operation. F is the rod or tail of the valve passing through a stuffing box above, and attached by a chain to the sector G, and by its means moving the lever that carries the ball H.

The above constitutes the whole of this simple and effectual contrivance, and its mode of operation scarcely needs to be described. As the steam becomes stronger it raises the valve, and escapes through D, and raises the weight H higher the more the pressure within exceeds that of the working steam in the upper space F E.

On Mr. Arthur Woolf's *improved apparatus, applicable to Steam Engines and other purposes of art and manufacture: including a description of two boilers now erecting at Messrs.* Meux's *Brewery.*

MR. WOOLF'S improved apparatus consists, First, of two or more cylindrical vessels properly connected together, and so disposed as to constitute a strong and fit receptacle for water, or any other fluid intended to be converted into steam, whether at the usual heats or at temperatures and under pressures uncommonly high; and also to present an extensive portion of convex surface to the current of flame, or heated air or vapour from a fire: Secondly, of other cylindrical receptacles placed above these cylinders, and properly connected with them, for the purpose of containing water and steam, and for the reception, transmission, and useful application of the steam generated from the heated water or other fluid: and, Thirdly, of a furnace so adapted to the cylindrical parts just mentioned, as to cause the greater part of the surface of all and each of them, or as much of the said surface as may be convenient or desirable, to receive the direct action of the fire, or heated air and vapour.

That our readers may be able fully to comprehend the way in which Mr. Woolf constructs his apparatus, we shall present some plans and views, with such a description as will, we hope, convey a pretty correct idea of their nature.

Fig. 1. (Plate II.) represents one of his boilers in its most simple form. It consists of eight tubes marked *a*, made of cast iron or any other fit metal, which are each connected with the cylinder A placed above them, as shown in the side view fig. 2, in which the same letters refer to the same parts as in fig. 1. In fig. 2. is also shown the way in which the fire is made to act. The fuel rests on the bars at B, and the flame, heated air and vapour, being reverberated from the part above the two

first smaller cylinders, goes under the third, over the fourth, under the fifth, over the sixth, under the seventh, and partly over partly under the eighth small cylindric tube. The direction of the flame, till it reaches the last-mentioned tube, is shown by the dotted curved line and arrows. When it has reached that end of the furnace it is carried by the flue C to the other side of a wall, built under and in the direction of the main cylinder A, and then returns under the seventh smaller cylinder, over the sixth, under the fifth, over the fourth, under the third, over the second, and partly over partly under the first; when it passes into the chimney. The wall before mentioned, which divides the furnace longitudinally, answers the double purpose of lengthening the course which the flame and heated air have to traverse, giving off heat to the boiler in their passage, and of securing from being destroyed by the fire the flanges or other joinings employed to unite the smaller tubes to the main cylinder. The ends of the smaller cylindric tubes rest on the brick-work which forms the sides of the furnace, and one end of each of them is furnished with a cover, secured in its place by screws or any other adequate means, but which can be taken off at pleasure, to allow the tubes to be freed, from time to time, from any incrustation or sediment which may be deposited in them. To any convenient part of the main cylinder A, a tube is affixed, to convey the steam to the steam-engine, or to any vessel intended to be heated by means of steam.

When very high temperatures are not to be employed, the kind of boiler just described is found to answer very well; but where the utmost force of the fire is desirable, Mr. Woolf, for a reason which shall be afterwards mentioned, combines the parts in a manner somewhat different, though the same in principle. Having been permitted to inspect two boilers of this kind which he is now

erecting in Messrs. Meux's* brewery, and even to take copies of such parts of the plans as were necessary for our present purpose, we persuade ourselves a short description of an apparatus so curious, and at the same time so useful, will prove highly acceptable to our readers.

In fig. 3, A is the main cylinder crossing the smaller cylinders *a*, *a*, *a*, half way between their middles and ends, but not joined to them at the points at which it crosses them. It is put in this place that it may come over that part of the furnace S, S, S, through which the flame first passes, and receive its direct action, which it does over nearly a half of its surface, as may be seen by looking at the vertical section A S S, fig. 6. The smaller cylinders have a communication with the main cylinder in the following manner :—Three cylinders, CCC, are placed parallel to the main cylinder A, over the part of the furnace by which the flame returns, in such a manner that each of the cylinders CCC takes in three of the smaller cylinders *a a a*, being united to and connected with them as shown in fig. 4, which is a longitudinal vertical section of that part of the apparatus. The cylinders CCC have a direct communication with the main cylinder A by the pipes or tubes P P P, as may be better seen by the cross vertical section, fig. 6, in which the same parts are marked with the same letters as in figures 3 and 4. The three tubes CCC are preferred to one long tube, to prevent any derangement taking place in the furnace or in the tubes, by the expansion and contraction, occasioned by changes of temperature, which is more considerable in one tube of the whole length of the furnace, than when divided into three portions ; and it is for the same reason that the tube A is not made to communicate directly with the smaller tubes *a a a*, but mediately by means of the tubes marked C and P.—N. B. The two outermost of the tubes marked P, instead of going parallel to the middle tube P,

* The Meux's, are the greatest Porter Brewers in England.

may both be inclined towards it, as one of them is from *m*, so as to join the cylinder A near the middle; or any other direction may be given to them, to prevent derangement by expansion.

The tubes C and *a* are kept from separating by bolts from the inside of *a* passing through the top of C, where they are secured by nuts screwed on to them (see fig. 5.); and these parts of C are so contrived, that by taking off any of the nuts a cover may be removed, and a hole presented large enough to admit a man's hand into C to clean it out.

Fig. 5 is a longitudinal vertical section of the boiler and furnace, through the centre of the axis of the main cylinder A, showing the course which the flame and heated air are forced to take. The first three small cylinders are completely surrounded with flame, being directly over the fire: the flame is stopped by the brick-work W over the fifth, and forced to pass under it, and then over the sixth, where it again meets with an interruption, which forces it to go under the seventh, over the eighth, and partly over partly under the ninth. It then turns round the end of the longitudinal wall which divides the furnace, and passes over the eighth smaller cylinder, under the seventh, and so on alternately over and under the other tubes, till it reaches the chimney B, fig. 4. The wall that divides the furnace may be seen in fig. 3, N, N, and in fig. 6, at N.

To secure a free communication between the different parts of the boiler, the three tubes of the middle cylinder C are connected with those of the two exterior C's by two pipes *o o*. The other ends of the tubes *a a a* are each fitted with a cover properly secured and bolted, but which can be taken off occasionally to clean out the boiler.

In working with such boilers, the water carried off by evaporation is replaced by water forced in by the usual

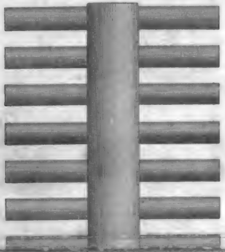
means; and the steam generated is carried to the place intended, by means of tubes connected with the upper part of the cylinder A.

Mr. Woolf has taken out a patent for this very valuable contrivance. In the specification he has lodged of his invention, means are pointed out for applying it to the boilers of steam-engines already in use, by ranging a row of cylinders below the present boiler, and connecting them with each other and with the boiler. Directions are also given for constructing boilers composed of cylinders disposed vertically; but as we consider such an arrangement inferior to the horizontal, and as being introduced, perhaps, chiefly for the purpose of preventing his patent from being infringed by evasion, we shall not give any further description of it. We cannot, however, dismiss this article without quoting some of Mr. Woolf's remarks, which may prove very useful.

"It may not be improper (says he) to call the attention of those who may hereafter wish to construct such apparatus to one circumstance, namely, that in every case the tubes composing the boiler should be so combined and arranged, and the furnace so constructed, as to make the fire, the flame and heated air to act around, over and among the tubes, embracing the largest possible quantity of their surface. It must be obvious to any one that the tubes may be made of any kind of metal; but I prefer cast iron as the most convenient. The size of the tubes may be varied: but in every case care should be taken not to make their diameter too great; and it must be remembered, that the larger the diameter of any single tube in such a boiler the stronger must it be made in proportion, to enable it to bear the same expansive force as the smaller cylinders. It is not essential, however, to my invention that the tubes should be of different sizes; but I prefer that the upper cylinders, especially the one which I call the

Mr. Woolf's Boiler.

1



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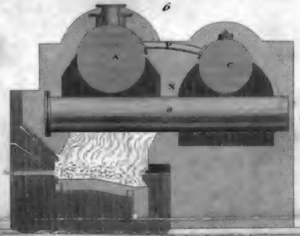

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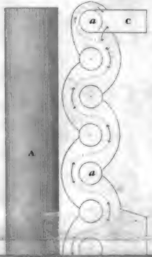


2

main cylinder, should be larger than the lower ones, it being the reservoir as it were into which the lower ones send the steam, to be thence conveyed away by the steam pipe or pipes. The following general direction may be given respecting the quantity of water to be kept in a boiler on my construction:—it ought always to fill not only the lower tubes, but the main cylinder A and the cylinder C to about half their diameter; that is, as high as the fire is allowed to reach—and in no case ought it to be allowed to get so low as not to keep full the necks or branches which join the smaller cylinders, marked with the letter *a*, to the cylinders A or C; for the fire is only beneficially employed when applied, through the medium of the interposed metal, to water, to convert it into steam: that is, the purpose of my boiler would in some measure be defeated, if any of the parts of the tubes exposed to the direct action of the fire should present in their interior a surface of steam instead of water, to receive the transmitted heat, which must more or less be the case if the lower tubes, and even a part of the upper, be not kept filled with the liquid.

"As to the construction of the furnaces, though that must be obvious from the drawings, it may not be improper here to remark that they should always be so built as to give a long and waving course to the flame and heated air, or vapour, forcing them the more effectually to strike against the sides of the tubes which compose the boiler, and so to give out a large portion of their heat before they reach the chimney: unless this be attended to, there will be a much greater waste of fuel than necessary; and the heat communicated to the contents of the boiler will be less from a given quantity of fuel.

"My invention is not only applicable to all the uses to which the boilers in common use are generally applied, but to all of them with much better effects than the latter,

and can besides be applied to purposes in which boilers, constructed as they have hitherto been, would be of little or no use. The working of all kinds of *steam engines* is one important application of my invention; for the steam may be raised, in a boiler constructed in the manner before described, to such a temperature, and consequently to such an expansive force, as to work an engine even without condensing the steam, by simply allowing it to escape into the atmosphere after it has done its office, as proposed by Mr. James Watt, in the specification of his patent, dated January 5, 1769: where he says, engines may be worked by the force of steam only, by discharging the steam into the open air. In all cases where it is desirable to heat or boil water, or other fluids and substances, without the direct application of fire to the vessel or vessels containing them, which in such cases become secondary boilers, the use of my apparatus will produce effects superior to any obtainable by other means—no more being necessary than to make the vessel, or secondary boiler, containing the water or other fluids, and the substances immersed or dissolved in, or blended or mixed with the water or other fluid, to communicate, by means of a tube or tubes, with the prime boiler, constructed in the manner before described. In such cases, as in making extracts of every kind for the various purposes of arts and manufactures, and for the simple boiling of water or watery fluids, the steam should go directly into the vessel, or secondary boiler, whose contents are to be heated or boiled; and the orifice or orifices of the pipe or pipes through which the steam is conveyed should go to a considerable depth in the fluid, that the steam may be the better able to give off its heat and be condensed before it can reach the surface: and in every such case, an allowance should be made for the increase which will be made to the quantity of liquid in the vessel to be heated.

by the quantity of steam which will be condensed in the same before the process be ended. The vessels into which the steam is thrown may be either open or close, as the nature of circumstances may require: but where extracts are to be made from vegetable or other matters from which extracts are or may be made, as from hops, bark, drugs and dye-stuffs, for brewing, tanning, dyeing and other processes, the materials will be much more completely exhausted of all their valuable parts; and in many instances they will be completely dissolved by employing close vessels, which in that case must be made very strong,—a thing not difficult to be accomplished, when it is recollected that they may be at a distance from, and consequently out of the power of being deranged by, the fire, and that they may be surrounded with, and as it were buried in, massy stone or brick-work, in addition to other and obvious means of securing them. My apparatus so employed becomes, in fact, an improved Papin's digester on a large scale. I do not wish to be understood as claiming the merit of having been the first who applied steam in the manner just described to boil water and other fluids, but merely as pointing out an important use to which my apparatus is applicable, and in which the effect obtained will be much greater than by any other means.

"Another important use to which my invention can be applied with better effect than the means now in use, is that of *distillation* on the large scale, and that by either sending the steam directly into and among the contents of the still or alembic, or by inclosing the still in another vessel, and making the steam of a high temperature, to circulate in and to occupy the space between the exterior surface of the still and the interior surface of the containing vessel. In either case, all danger of burning or singeing the materials operated upon is done away, and a much more pleasant and pure spirit will be obtained than by the

methods now in common use. I need not stop here to shew the reason why, even in the case of throwing the steam directly into the still, the spirituous part will be the first to rise and pass over into the receiver.

"I might mention many other useful applications that may be made of my invention; but I shall only state one more, namely, to the drying of *gunpowder*, and lessening the danger of explosions in the manufacture of that article. By means of my invention, any desired temperature, necessary for that purpose, may be produced where the powder is to be dried, without the necessity of having fire in, or so near the place as to endanger its safety; for by employing steam only, conveyed through pipes, and properly applied and directed, without allowing any of it to escape into the room or apartment where the powder is, any competent workman can produce a heat equal to that found necessary for drying gunpowder, or much higher if required. Nor is the lessening of the danger of explosions the only advantage which this way of drying gunpowder holds out—it presents another and an essential one for the goodness of the article—the heat can be completely regulated so as to prevent, or at least lessen, the partial decomposition of the powder by the sublimation of the sulphur, which is found to take place by the methods at present in use."

In every case Mr. Woolf uses two safety valves at least, in his apparatus, to prevent accidents: a precaution which cannot be too strongly enforced; as it may happen, when but one is employed, it may by some accident get locked, and the works and people about them be exposed to the danger of an explosion.

Besides the common safety valves, Mr. Woolf has also introduced a valve, of a new construction, into the steam-pipe itself, to regulate the quantity that shall pass from the boiler. In fact, it is a self-acting regulator; and

being extremely ingenious, we think we shall be gratifying our readers by laying a description of it before them, which we shall in our next, with an accurate engraving.*

The two boilers now constructing for Messrs. Meux will not be the least curious part of the immense collection of ingenious mechanism of which their premises can boast. They are not intended for the steam engine, but to supercede the necessity of applying fire directly to their two large boilers, each of which are of the contents of about 800 barrels. They are in future to be heated by steam, sent into them from these new boilers; which will not only prevent the wear to which the coppers are exposed by the usual practice, which costs a large sum of money yearly, but, it is expected, will produce a large saving in fuel.

We understand also, that when these boilers are finished Messrs. Meux mean to have one constructed for their steam engine. Indeed, if these boilers shall be found to answer the purposes expected from them, and we can see no reason to induce us to doubt of their success, it will occasion a complete change in numerous departments of arts and manufactures, in which steam and the heat that may be obtained from it are, or may be, advantageously employed.†

Description of Mr. Arthur Woolf's improved Piston for Steam-Engines.

THE common method of packing the piston of a steam engine is so well known, that a very particular description of it in this place is not necessary. Suffice it to say, that the hollow part round the piston, is filled

* Already given in this number.

† Mr. Woolf has adopted for the door of his furnace Mr. Robertson's invention for consuming smoke. See beginning of this volume.

with rounds of hemp or cotton, loosely spun or twisted, which is pressed into a pretty compact form by a ring, which is worked down by screws distributed round the ring and working into the body of the piston; by which means the packing is made to fill the diameter of the cylinder pretty closely, and to prevent, while the packing remains sound, any steam from passing between the piston and the cylinder. In the usual method, whenever the piston, by continued working, becomes too easy, and so occasions a waste of steam, it is necessary to take off the top of the cylinder, even when fresh hemp or cotton is not wanted, merely to get at the screws, which serve to force the upper ring nearer to the bottom of the piston, by which means the packing is forced outwards against the side of the cylinder. This is heavy laborious work, and is therefore generally shunned by the man that attends the engine, as long as the engine can possibly be made to work without taking this trouble; and in consequence of this neglect a great and unnecessary waste of steam is occasioned, and a waste of fuel in proportion.

Mr. Woolf's improvement on the piston is such as to enable the engine-man to tighten the piston without the necessity of taking off the cover of the cylinder, except when new packing becomes necessary. He accomplishes this by either of the two following methods:

He fastens each of the screws into a small wheel, which are all connected with each other by means of a central wheel, which works loose upon the piston-rod in such a manner, that if one of the small wheels be turned, it turns the central wheel, and the latter turns the other four. The one that is to be first turned is furnished with a projecting square head, which rises up into a recess in the cover of the cylinder. This recess is surmounted by a cap or bonnet, which being easily taken off, and as easily put again in its place, there is little difficulty in screw-

ing down the packing at any time. The parts are so clearly expressed in the plates that no further description is necessary to make any person comprehend it.

The other method is similar in principle, but a little different in construction. Instead of having several screws all worked down by one motion, there is in this but one screw, and that one is a part of the piston-rod: on this is placed a wheel of a convenient diameter, the centre of which is furnished with a female screw. This wheel is turned round, *i. e.* screwed down by means of the pinion, which is furnished with a square projecting head rising into a recess of the kind already described. The ring is prevented from turning with the wheel by means of two steady pins.*

Description of a Safety Valve, containing a Vacuum Valve in the same Hole of the Boiler. By Sir A. N. EDELCRANTZ.†

IN large boilers or coppers, where boiling fluids are enclosed, a *safety valve* is generally used to prevent their bursting, from an unexpected excessive force of the elastic steam, and, besides, a *vacuum valve*, to prevent their being compressed or crushed by the weight of external air, in the case of a sudden condensation of the vapours. These two valves are commonly fitted in two different holes in the boiler; but as a more simple, and consequently more eligible, method seems to be that of joining them together, I take the liberty to submit to the Society for the Encouragement of Arts, &c. the following contrivance for that purpose:—

a b, Plate III. Fig. 2. is a common conical safety valve,

* There is a plate describing this in 26 Phil. Mag. 317, which I have not thought it necessary to copy. T. C.

† From the Memoirs of the Society of Arts for 1804. The silver medal was awarded for this invention.

fixed in the boiler *c d*, having four openings, *i i*, which are represented in a plain view in *Fig.* 3: *e f* is the metallic rod, bearing the weight K K, with which the safety valve is loaded, and extending itself under that valve to *f*: *g h* is the *vacuum valve* consisting in a plane circular plate, with a brass tube sliding across the rod, and pressed by a spiral spring to the safety valve *a b* (against which it has been well ground in making it), closing in that situation the openings *i i*.

Such being the construction of the whole, it is evident, that when the elasticity of the steam increases, the two valves, joined together, with the holes *i i* shut, make but one, opposing to the elasticity of the steam an united resistance, which is regulated by the weight *k k*, in the common way; but, on the contrary, when by condensation of the vapours a vacuum is produced, the external air in pressing through *i i*, upon the vacuum valve *g h*, forces it down, and opens to itself a passage into the boiler.

The valve *g h* may easily be made conical, like the other, if that form should be preferred; but in different trials, I have found planes, if well-turned and ground together, join as perfectly as can be desired, being pressed by the united elasticity of the spring and the steam.

Fig. 4. is the same contrivance adapted to a new kind of *safety valve* or *piston*, which, though I originally intended it for the use of Papin's digesters of a new construction,* has been, in a larger size, applied by me to steam engines, and is described in the Philosophical Magazine of December, 1803.†

* Nicholson's Journal, March, 1804.

† The description of this contrivance being already published, it would be superfluous to repeat it. I only beg leave to add the following practical remark. A metallic piston, if well turned and fitted into a cylinder of exactly the same kind of metal, will probably have the same degree of expansion, especially if hollow, and consequently will not increase its friction in any increased degree

I have lately begun, and shall pursue, a set of experiments, with the intention of regulating by this safety piston, the quantity of admitted air to fire-grates, and to effect, by that means, a new mode of regulating the fire, and the elasticity of steam in boilers, with less expenditure of fuel and of force than usual; of which idea a hint is given in the work and place above mentioned. The result of these researches I shall at some future period do myself the honour of communicating to that society.

Description of a new Boiler constructed with a view to the saving of Fuel. By BENJAMIN COUNT OF RUMFORD. *Read at a Meeting of the first Class of the National Institute the 6th October*, 1806.

IT is well known that much is gained in the saving of fuel, when an extensive surface is given to that part of the boiler against which the flame strikes, but this advantage is often counterbalanced by great inconveniences. For a boiler of the form usually employed, having the bottom very much extended in proportion to its capacity, must necessarily present a great surface to the atmosphere, and the loss of heat, occasioned by the cold air coming in contact with this surface, may be more than sufficient to compensate the advantage derived from the extended surface of the bottom. And where the boiler is employed for producing steam, as it is indispensably necessary that it should be of a thickness sufficient to resist the ex-

of temperature. But as in practice the cylinder is commonly exposed to a lower temperature than the piston, heated by the steam, a little increase of friction will take place by an increase of heat. To prevent the effect of this, I have found it useful to employ for the piston a metal of somewhat less expansive power than the cylinder: and the expansion of red copper being to that of brass nearly as 10 to 11, I prefer making the piston of the former metal, when the cylinder is made of brass.

pansive force of the steam, it is evident, that if the diameter be augmented (with a view to increase the surface of the bottom) a considerable expence is incurred on account of the additional strength that must be given to the sides.

Having been engaged in the year 1796, in a set of experiments, in which I employed the steam of boiling water as a vehicle of heat; I had a boiler made for this purpose, on a new construction, which answered well, and even beyond my expectations; and, as this boiler might be used with advantage in many cases, even where it is only required to heat liquids in an open boiler, this, and another motive, which it would be useless to mention in this place, have lately induced me to construct one here (at Paris) and to present it to the Institute.

The object chiefly had in view in the construction of this boiler, was to give it such a form, that the surface exposed to the fire should be great in comparison with its diameter and capacity; and this without having a great surface exposed to the cold air of the atmosphere.

The body of the boiler is in the shape of a drum. It is a vertical cylinder of copper twelve inches in diameter, and twelve inches high, closed at top and at bottom by circular plates.

In the centre of the upper plate there is a cylindrical neck six inches in diameter, and three inches high, shut at top by a plate of copper three inches in diameter and three lines in thickness, fastened down by screws.

This last plate is pierced by three holes, each about five lines in diameter. The first, which is in the centre of the plate, receives a vertical tube, which conveys water to the boiler from a reservoir which is placed above. This tube, which descends in the inside of the boiler, to within an inch above the circular plate which forms its bottom, has a cock near its lower end. This cock is

alternately opened and shut, by means of a floater which swims on the surface of the water contained in the body of the boiler.

The second of the holes is the plate that closes the neck of the boiler, receives the lower end of another vertical tube, which serves to convey the steam from the boiler to the place where it is to be used.

The third hole is occupied by a safety valve.

This description shews that there is nothing new in the construction or arrangement of the upper part of this boiler. In its lower part there is a contrivance for increasing its surface, which has been found very useful.

The flat circular bottom of the body of the boiler, which as I said before is twelve inches in diameter, being pierced by seven holes, each three inches in diameter, seven cylindrical tubes of thin sheet copper, three inches in diameter, and nine inches long, closed below by circular plates, are fixed in these holes, and firmly rivetted, and then soldered to the flat bottom of the boiler.

On opening the communication between the boiler and its reservoir, the water first fills the seven tubes, and then rises to the cylindrical body of the boiler; but it can never rise above six inches in the body of the boiler, for when it has got to that height, the floater is lifted to the height necessary for shutting the cock that admits the water.

When the height of the water in the boiler is diminished a few lines by the evaporation, the floater descends a little, the cock is again opened, and the water flows in again from the reservoir.

As the seven tubes that descend from the flat bottom of the body of this boiler into the fire place, are surrounded on all sides by the flame, the liquid contained in the boiler is heated, and made to boil in a short time, and with the consumption of a relatively small quantity of

fuel; and when the vertical sides of the body of the boiler, and its upper part are suitably enveloped, in order to prevent the loss of heat by these surfaces, this apparatus may be employed with much advantage in all cases where it is required to boil water for procuring steam.

And as in the case where the boiler is constructed on a great scale, the seven tubes that descend from the bottom of the boiler into the fire may be made of cast iron, whilst the body of the boiler is composed of sheet iron, or sheet copper; it is certain that a boiler of this kind, sufficiently large for a steam engine, a dyeing house, or a spirit distillery, would cost much less than a boiler of the usual form, of equal surface and power.

But in all cases where it is required to produce a great quantity of steam, it will be always preferable to employ several boilers of a middling size, placed beside each other, and heated each by a separate fire, instead of using one large boiler heated by one fire.

I have shewn, in my sixth essay, on the management of fire, and the œconomy of fuel, that beyond a certain limit, there is no advantage derived from augmenting the capacity of a boiler.

It will be perceived, that the boiler which I have the honour of presenting to this society, is of a form fit for being placed in a portative furnace, and it was actually intended for that purpose.

Its furnace, which is made of bricks, with a circular iron grate of six inches in diameter, is built in the inside of a cylinder of sheet iron, seventeen inches in diameter, and three feet high, and can be easily transported from place to place, by two men.

This cylinder of sheet iron, which is divided into two parts, in order to facilitate the construction of the masonry weighs only forty-six pounds. The masonry weighs

about a hundred and fifty pounds, and the boiler twenty-two pounds.

In order to form an estimate of the advantage which the particular form of this boiler gives it in accelerating its heating, we may compare the extent of surface that it presents to the action of the fire, with that of the flat bottom of a common boiler.

The diameter of the bottom of a cylindrical boiler being twelve inches, the surface is 113.88 square inches; but the surface of the sides of the seven tubes that descend from the flat bottom of our boiler (which is likewise twelve inches in diameter) is 593.76 square inches. Therefore, the new boiler has a surface exposed to the direct action of the fire, more than five times greater than that of a boiler of equal diameter, and of the ordinary form: how much this difference must affect the celerity of heating is easy to conceive.

In the manner in which boilers are usually set, their vertical sides are but little struck by the flame, and on that account, I have not taken the effect of the sides into consideration in my estimate; but even taking them into account, the new boiler will always have a surface exposed to the fire, at least twice as great as that of a common cylindrical boiler of the same diameter, as can easily be shewn.

The new boiler being twelve inches in diameter, and twelve inches high, and each of its seven tubes being three inches in diameter, and nine inches high, its surface is 1160.44 square inches, without reckoning the circular plate that closes its top, nor its neck.

The surface of the bottom and sides of a cylindrical boiler of twelve inches in diameter, and twelve inches high, will be 566.68 square inches.

As the quantity of heat that enters a boiler in a given time, is in proportion to the extent of surface that the

boiler presents to the fire, it is evident, that other circumstances being the same, a boiler with tubes descending from its bottom, will be heated at least twice as soon as a cylindrical boiler of the same diameter, with a flat bottom.

In order that a cylindrical boiler with flat bottom, surrounded by flame on all sides, might have the same extent of surface exposed to the fire as a boiler with tubes, it would be necessary to give it a diameter greater than that of the boiler with tubes in the proportion of the square root of 1160.44, to the square root of 566.68, that is, of 17.171 to 12.

Therefore, in order that a cylindrical boiler with a flat bottom, might have the same extent of surface exposed to the fire as our boiler with tubes, of twelve inches in diameter, it would be necessary to give it a diameter of 17.171 inches.

But if the diameter of a boiler intended for producing steam be increased, it is necessary, at the same time, to increase its thickness, in order to increase its strength.

The necessary increase of thickness, and the expence that it will occasion, can be easily calculated.

The effort that an elastic fluid exerts against the sides of the containing vessel, is in proportion to the surface of a longitudinal and central section of the vessel, and consequently in proportion to the square of its diameter, the form remaining the same. Hence we may conclude, that a steam boiler of a cylindrical form with a flat bottom, which has the same extent of surface exposed to the fire as a boiler of twelve inches in diameter with tubes, should be at least twice as thick as this last, in order to have an equal degree of strength for resisting the expansive power of the steam.

The boiler which I have the honour of presenting to the society, is particularly intended to serve as a steam

boiler, but it may undoubtedly be applied to other purposes. Having shewn it to M. Auzilly, son of a considerable soap manufacturer of Marseilles, he thought that it might be employed with advantage in the making of soap; and from what he told me of the process, and of the boilers employed in that art, I am persuaded that the experiment would succeed perfectly.

But after all, it remains to be determined, whether it would not be still more advantageous to employ steam as a vehicle of heat in the making of soap, instead of lighting the fire under the bottom of the vessel in which the soap is made.

The result of an experiment which we are to make, M. Auzilly and myself, will probably throw some light upon this question.—17 *Nicholson's Journal, p.* 5.

The boiler recommended by Count Rumford is by no means a new contrivance. Mr. Stevens obtained a patent in 1805 (the specification of which may be seen in the Repertory of Arts, Vol. vii. p. 173.) for a boiler formed in a similar manner, by a number of tubes placed parallel to each other, and communicating with a flat vessel at one of their extremities; the number of the tubes to be used was not defined by Mr. Stevens, and the capacity of the vessel that received the ends was much less than that here described, and though this must occasion some difference of external appearance, the principle is undoubtedly the same in both.

There is no account of comparative experiments made with this new boiler and others, to enable us to decide on its merit. But as far as can be judged from a knowledge of various other experiments on boilers, we cannot have any good expectations of this form for boilers. The great additional workmanship necessary for it, must add considerably to the expence; and the very remark which the

Count makes on the advantage of numerous small boilers, with each a *separate* fire-place, shews that he was at least doubtful in recommending the use of this on a large scale.

The Count has made a considerable mistake in asserting that an equal surface will have more strength to resist internal pressure in a boiler of the shape proposed than in one of the common form; the sum of the pressure in all boilers, with the same force of steam, is demonstrably as their internal surfaces, and the only difference the form makes, is, that globular forms are least liable to have their shape altered by the pressure, flat forms most, and the intermediate shapes more or less so, as they most resemble the flat or globular form.

A variety of plans have been tried to make the same quantity of fuel produce greater effects by some particular formation of the boiler; among these, none seem superior to that for which Mr. Edmond Lloyd, in the Strand, obtained a patent, in simplicity or effect; the principle has hitherto been used chiefly for kettles, and other small vessels made for sale by Mr. Lloyd; but there is no cause why it should not do equally well for large boilers; and there is reason to think that they would be much preferable to the Count's new boiler, and would certainly cost much less.

One of the kettles of this form will boil two quarts of water in less than ten minutes, with less than a third of one of the common penny bundles of fire-wood, sold every where in London. As a description of the principle on which they are made may be acceptable, the following account of it is presented to our readers, to most of whom, we believe, it will be novel.

Description of Mr. Lloyd's Patent Boiler for quick boiling and saving fuel.

The bottom of each of Mr. Lloyd's boilers is introverted, so as to form a cavity which would nearly hold as much as the boiler itself, if it were reversed; the sides of this cavity are somewhat conoidal, and from the top a pipe passes out at one side through the cavity of the boiler to the air; the whole boiler or kettle, is surrounded by an external case, a little distant from it all round, closed at top, and having a small opening at the side to give vent to the smoke. The small pipe adds somewhat to the effect, but is not absolutely necessary. For large boilers the cavity at the bottom need not be so large in proportion as that described, if it rises into the boiler a third of its depth, it will probably be sufficient. The flame and radiant heat of the fuel is reverberated in all directions in the cavity of the hollow bottom, and must have much more effect than what can be produced by its unconfined lateral action against the external sides of a number of upright pipes however well arranged; indeed Count Rumford has shewn in former papers, the value of the lateral action of fire against the sides to be so small, that we are surprized to see him recommend the apparatus above described, in which the chief effect produced must arise solely from a similar lateral action of the fire.

*Account of a successful exprim*ent *in making soap by the operation of steam, instead of an open fire, communicated by Count Rumford to the French National Institute. Phil. Journ. No.* 71.

The steam was conveyed into the vessel, which contained the ley and other materials for the soap, by a pipe arising from a close boiler, and again descending into the vessel; the action of the steam in condensing in the cold ley, occasioned a succession of smart shocks, similar to

blows of a hammer, which caused the whole apparatus to tremble, but which gradually subsided as the liquid became warm. Count Rumford supposes, that the beneficial action of the steam depends for the most part on the motion described, caused by it, and therefore proposes dividing the vessel into two parts by an horizontal partition of thin copper, and causing a slow current of cold water to pass through the lower division, and to let the steam into this lower part, when the upper became too hot to admit of a continuation of the strokes from the condensation of the steam; by which means the same motion being continued in the cold water, would be communicated to the hot liquid through the thin partition.

The soap made by the operation of the steam, required only six hours boiling, whereas sixty hours and more are necessary in the ordinary method of making soap. 2 *Athenæum* 66.

Familiar account of the method of estimating the value of a Steam Engine in horse-powers as they are called. By a correspondent.

To Mr. NICHOLSON.

Sir,

AS your excellent journal is the repository for useful information, whether scientific or practical, I have thought I should oblige many manufacturers and others of your readers, by sending you a very clear report about horse-powers, which a friend of mine has communicated to me, and was received by him from an eminent character in answer to an enquiry professionally made.

It clearly appears from this paper, that the calculation by horse-powers must be fallacious, unless engineers could agree as to the quantity of work they would arbitrarily, in the first instance, ascribe to one horse; and then the expression would be nugatory. And not only so, but it would not then be true that the value of a steam

engine in work, however clearly expressed in quantity *per* day, would be fairly shewn, unless the wages or food of the working being were taken into the account. Coals may be stiled the food of a steam engine, and nothing is more evident than that, if two engines raise equal quantities of water *per* hour, but consume different quantities of coal, they will not be equally beneficial to the proprietors. I would therefore propose, that the estimate should be made by attending to these two particulars only, and saying nothing about horses, at least in specific arguments intended to have legal effects: And, as a supplement to the facts and observations contained in the report, I will add, that one of the best engines of Boulton and Watt, has been known to raise between 28 and 30 millions of pounds of water to the height of one foot with one bushel of good coals, which appears to be an outside measure; and that, though there are subsequent improvements both in the construction of furnaces and the working gear, yet there are some among late engines which fall short of 20 millions.

I am, Sir,

Your constant reader,

E. T.

*Report concerning the power of a Steam Engine erected by contract at * * * *.*

IT is required to determine whether the steam engine erected at * * * * by Mr. ——, be equal to the power of sixteen horses. The same has a cylinder of $21\frac{1}{8}$ inches diameter, and gives 23 double strokes *per* minute, of four feet each.

In answer to this question it must be previously remarked, that steam engines having originally been recommended and substituted instead of horses, the method of computing by the number of those animals intended to be supplied by means of this invention, has been general-

ly applied, though it is much less certain and accurate than other methods well known to mechanical men. The uncertainty of calculating by horse-powers arises from various causes; such as the great differences of ability between the strong and heavy horses used in London, and those of not half the strength used in various parts of the country; the greater or less degree of speed during work; the quantity of re-action against which they are urged to pull; the shorter or longer time of work; their food, stabling, &c. &c. And this uncertainty, as may easily be conceived, is so great, that the words *horse-power* cannot practically be applied, otherwise than to denote a certain quantity of mechanic effect agreed upon and understood between engineers, and must not be understood to denote any elementary measure, capable of being worked out or inferred within any reasonable or useful limits, from the real power of the horse himself.

It therefore follows of necessity, that the engine must be examined by first stating its mechanic effect; that is to say, how many pounds weight it is capable of raising through a given space in a given time, that is to say, through the height of one foot during one minute, and then dividing this sum by the like effect producible by one horse, according to the statements and practice of engineers of the first reputation. I confine myself to Messrs. Boulton and Watt, Dr. Desaguliers and Mr. Smeaton.

The practice of Messrs. Boulton and Watt is, to consider a horse as capable of raising a certain weight, which is stated to be of 33,000 pounds avoirdupois, one foot high in one minute. Desaguliers' results brought to the same form, give 27,500 pounds; and Smeaton's 22,916 pounds, under the same circumstances. The lowest of these performances are more than equal to the average power of a horse employed in husbandry for eight hours *per* day.

If the diameter of the cylinder be multiplied by itself

(21 1-8 × 21 1-8), the product will give 446 1-4 round inches for the whole surface: and Smeaton reckons the effective or working pressure *per* round inch on the atmospheric engine, at seven pounds avoirdupois. It is usual to reckon the working pressure on a close engine (like that in question), at 10 pounds the round inch; but I shall first take the seven pounds as being against the builder: So that, by multiplying the round inches 446 1-4 by 7, we have 3123 3-4 pounds for the weight raised. But the strokes are 23 of four feet double *per* minute, that is to say, 184 feet. Multiply the weight 3123 3-4 by the height 184, and the product 574760 will be the mechanic effect of the engine, or the number of pounds it will raise one foot high in one minute. Lastly, divide this by Boulton and Watt's horse-power ($\frac{574760}{32000}$), and the quotient $17\frac{15}{16}$, or very nearly 18, will express the power of the engine in horses.

If we follow Desaguliers, the engine will prove equal to 21 horses.

And, according to Smeaton, its power will be equal to 25 horses.

If we had taken the pressure at 10 pounds *per* round inch, the powers would have proved much greater, as below.

In the above calculations the horses are supposed to be fairly worked, and the engine is supposed to be stopped as soon as the horses leave off. But an engine can work the whole 24 hours; and Smeaton, considering that three setts of horses must be kept to work constantly for the same time, reckoned a steam engine to be equivalent to three times as many horses as could equal its rate of working. The following table will shew the powers of this engine, according to all these several methods:

	Power in horses according to Boulton and Watt.	Do. according to Desaguliers.	Do according to Smeaton.	24 hours work according to Smeaton in horses.
7lb. pressure per round inch.	$17\frac{96}{100}$ or 18 very nearly	21	25	75
10lb. pressure per round inch.	25	30	$35\frac{3}{4}$	107

9 *Nich. Journ.* 214.

Remarks on the estimation of the Strength of Horses. In a letter from Mr. O. Gregory, *of the Royal Military Academy, Woolwich.*

To Mr. NICHOLSON.

Sir,

The remarks of your ingenious correspondent, Mr. Hornblower, on the various estimates of the *Power of a Horse*, and the absurdity of adopting a quantity so fluctuating and so difficult to ascertain, as a common measure by which the powers and effects of steam engines and other machines are to be estimated and compared, have induced me to throw together a few observations on the same subjects; the theoretic part of which, though familiar to most men of science, seems not to be always known, or at least recollected, by some persons who are employed in the practice; and which are altogether much at your service for insertion in the Journal, if you think them likely to be of any utility.

Dr. Desaguliers has given another estimate of the labour of a horse, beside that mentioned by Mr. Hornblower, and which indeed does not seem very consistent with it; for in vol. II. p. 251. of his Experimental Philosophy, he affirms that a horse in an advantageous situation, is able to draw 200lbs. eight hours a day, walking at the rate of 2 1-2 miles in an hour, or 3 2-3 feet in a second. This statement of the power of a horse, though it is not so great as that which is arbitrarily assu-

med by Messrs. Boulton and Watt, exceeds the determination of M. Sauveur, who estimates the mean effort of a horse at 175 French, or 189 avoirdupois lbs. with a velocity of rather more than three feet per second; and it probably exceeds Mr. Smeaton's statement of 550lbs. moved 40 feet in a minute; though, as will soon be seen, we are not furnished with proper data to institute a comparison between these various results. It is probable, however, as observed by the ingenious contributor of the article at page 216, vol. IX. of your Journal, that "the lowest of these performances is more than equal to "the average power of a horse employed in husbandry "for eight hours per day." So far as my own observations on this point extend, I am inclined to conclude that the average work of a stout London cart horse, for eight hours in a day, is little if any more than 130lbs. moved at the rate of three feet in a second, or 2 1-22 miles *per* hour. But this it would be ridiculous to assume positively as a universal unit of measure, in a case where the causes of variety are so numerous, and my opportunities of experiment comparatively few. The estimate just given, it should be observed, is not intended to express what a horse can draw upon a wheel carriage, where friction alone is to be overcome, after the load is once put into motion, and where a horse will often draw much more than 1000lbs. but the weight which a horse would raise out of a well, &c. the animal acting by a horizontal line of traction turned into the vertical direction by a simple pully or roller, whose friction is reduced as much as possible.*

Before we can institute any comparison between the

* The late Mr. More, Sec. to the Society of Arts, found by the interposition of a graduated spring instrument between the horse and his work, that the re-action was between 70 and 80lb. when the velocity was three miles in an hour. I think the work was ploughing. See Philos. Journal, quarto, vol. III. 136. N.

results of different experiments, it will always be necessary to enquire what machine was interposed between the weight moved and the animal, in each case, that we may thence deduce the real velocity with which the animal moved, from the velocity of the weight or load given by the observations. This is too frequently omitted in consequence of an implicit reliance upon a maxim, which, though highly useful under proper restrictions, is far from universal in its application. In the case before us, if we admit the maxim now alluded to, namely, that *what is gained in power is lost in time*, with regard to the machine through whose intervention the velocity of the weight is rendered different from that of the horse, it would be unsafe to adopt it in the appreciation of the varied energy of the animal when moving with different velocities. The reason of this is obvious. The energy of the horse is obliged to be employed not only in overcoming the weight or resistance which opposes his progress, but in part in moving *himself;* for the particles which constitute his frame possess weight and inertia, and therefore cannot be put into motion without effort. Hence it follows that there is a certain velocity, which may be denoted by U, with which, when the animal moves, his whole power will be employed in producing his own motion solely, without being able to move any other body. If a body whose mass is M be attached to the horse, so that he cannot move without giving an equal velocity to the extraneous body, the same effort being employed both in moving the animal and the mass attached; the velocity V, with which they move must necessarily be less. And if M be farther increased while the weight and energy of the horse continue the same, the velocity V will be still farther diminished; and thus as M increases V will diminish, until when M arrives at a certain magnitude, W, the animal is unable to make any progressive motion, and exerts his force at what is

called a dead pull. If M exceeds W, then will V become negative, and instead of the animal advancing with the load, the load will compel him to move backwards and no useful work can be accomplished.

Now these circumstances may be expressed algebraically, by the general formula $M \propto (U-V)^n$, in which the exponent n can only be determined by means of judicious and numerous experiments, where the magnitude of M should be ascertained for many variable values of V between the terms $V=U$, and $V=o$. From this theorem, following the common rules for the maxima and minima of quantities, it may readily be found that in order to have the *useful* work done the greatest possible, we we must increase or decrease the weight till V becomes $=\frac{U}{n+1}$, when the performance will be denoted by

$$\frac{n^n}{(n+1)^{n+1}} \times WU$$

And if the value of V thus exhibited be once ascertained experimentally, we need never be apprehensive of a material loss by a small variation from it; for by a well known property of those quantities which admit of a proper maximum and minimum, a value assumed at a moderate distance from either of these extremes will produce no sensible change in the effect.

In some of the actions of men, such as dragging a boat along a canal, &c. the value of n in the preceding theorems has been found to be nearly $=2$. And the draught of horses is conformable to a law not widely different. The best experiments which have yet been made on this point with regard to horses drawing in nearly rectilinear paths, lead us to conclude that n is then very nearly $=\frac{2}{4}$, in the expression $M \propto (U-V)^n$. Assuming therefore, for the utmost walking velocity of a horse, the value

$U=9$ feet per second, a value which is quite high enough, any proposed estimates of the strength of this animal may be compared with facility. Thus, for example, let us enquire which is greater, the estimate of Mr. More (mentioned by Mr. Hornblower) of 80lbs, three miles per hour, or $4\frac{2}{5}$ feet per second; or that of 130lbs. moved at the rate of three feet per second? Here we shall have

$$(9-3)^{\frac{9}{4}} : (9-4\cdot4)^{\frac{9}{4}} : : 130 : 71\tfrac{1}{2}\text{lbs. nearly.}$$

The operation may easily be performed by means of a table of logarithms, and shews that the mean estimate I have laid down, when reduced to the same velocity as that by Mr. More, furnishes a result less than his by $8\frac{1}{2}$lbs. Which of these is the most accurate can only be determined by future experiments.

If, however, either of these estimates should be adopted, it may be proper to remark that they would not hold with regard to the power of horses working in circular paths; yet, if it be at all proper to use *horse-powers* in estimating the energy of machines, it seems most natural to take these powers as exerted by the animal in a round walk; so that it is still necessary to have a series of experiments to determine the values of n, and the relation of M and V when horses draw in circular walks of different radii. I say, of *different* radii, because it is certain that *cæteris paribus*, the greater the radius of the circle in whose circumference the animal moves, the less fatigue will be occasioned by that kind of motion. Indeed it is obvious, that since a rectilinear motion is the most easy and natural for the horse, the less the line in which he moves is curved, with the greater facility he will walk over it, and the less he need recline from the vertical position. Besides this, with equal velocity at the circumference, the centrifugal force will be less in the greater circle, which will proportionally diminish the friction of the cylindrical part of the trunnions, and the labour of

moving the machine. And farther, the greater the radius of the horse-walk, the nearer the chord of the circle in which the horse draws is to coincidence with the tangent, which is the most advantageous position of the line of traction. Hence it follows, that although a horse *may* draw in a walk of 18 feet diameter, yet he will work with far greater ease in one whose diameter is 35 or 40 feet; and it is very desirable that an experimental enquiry should be made to ascertain the proportion and absolute quantity of work in different circles.

I am of opinion that it would not be difficult to make some useful experiments, while work was actually carrying on at any horse mill, or machine where horses are constrained to move in a circular walk. The simple drawing which accompanies this letter will assist in conveying a clear idea of the method which I fancy might be advantageously adopted. Let AB *Fig.* 1. *Plate* IV. be the vertical shaft to which the horizontal horse-poles AC, AD, are attached. Let one horse work the machine by drawing at the ear E; but, instead of the transverse bar to which the harness is fixed being simply hung upon the hook *h*, let a good spring steelyard be interposed between that cross-bar and the hook, the graduations of which shall, when the machinery is put into motion, indicate the resistance (in lbs.) overcome by the animal, including the weight of the mass moved, the friction, &c. Near the extremity of the opposite horse-pole AD, let there be fixed a strong and correct common steelyard, whose divisions shall shew the various weights from 40 or 50 to 200lbs. and whose centre of motion shall be at the point *f* on the fixed stand. Let the cord *c* which is fastened to the shorter arm of this steelyard, pass (with as little friction as possible) over the pulley *p*, and thus, being turned into the horizontal direction, or rather, inclining a little upwards, let it be fixed to the cross bar of the har-

ness of a second horse, equal in point of strength to the former. Then if the two horses, thus attached to the ears E and F, be made to pass over the walk in the same direction, following each other constantly at the distance of a semi-circumference; while that which draws at the ear E overcomes the whole pressure and resistance opposed by the work, the other which draws at F by the cord over the pulley *p*, will raise the weight *w* of the steelyard; which therefore, by being moved to and fro upon the arm *f i*, may be brought to exhibit an exact counterpoise, or measure of the exertion and power of the horse. And in order to ensure the greatest degree of accuracy in this respect, the motion of the two animals, and the position of the weight *w*, should be so adjusted, that the same weight should be shewn by the graduations both of the spring and of the lever steelyard. The shaking of the machinery will in some measure disturb the effect; but an ingenious manager of the experiments will find means of checking this: and as to the centrifugal force to which the weight *w* is exposed, it will never be of any material consequence in any of the slow motions which will be produced by this kind of work.

Each experiment should occupy the space of a fair day's work for the horses: for the conclusions deduced from shorter and irregular efforts are always erroneous in excess, and should be guarded against. The rate at which the animals move may readily be ascertained from the known circumference of the walk, and the number of rounds they are observed to make in 10 or 15 minutes. Thus, by continuing the experiments day after day, varying the velocity of the motion in some cases, and the radius of walk in others, such a series of results might at length be obtained, as would in a great measure remove the obscurity and doubt in which this business is at present enveloped. It is scarcely necessary to suggest the

propriety of making a few experiments with a view of determining how far a load upon the back of each draught horse, would assist him in his labour. Nor can it be requisite to point out in what way, by means of such steelyards properly applied to waggons, &c. upon tolerably smooth roads, and two horses marching abreast, (one drawing the load, the other raising the weight,) experiments might be instituted to ascertain the magnitude of the efforts of horses when drawing in rectilinear paths. Judicious experiments having these purposes in view, would certainly be beneficial, as they would enable us to tell what advantages might be expected from the labours of this useful quadruped in different circumstances. But with respect to the adoption of "*horse-power*" as a unit of force in estimating the power of steam engines, &c. I confess that if it were as well known, and as unvariable as the length of the day of the equator, I should feel an aversion to applying it to any such purpose. It is a common measure arbitrarily adopted, which has no necessary connection with the subject that is referred to it, which does not in any respect facilitate the computation of the powers of an engine, and which may, without proper caution, lead to considerable errors in the conclusions deduced from it.

Before I close this letter, already perhaps too long, I beg permission to say a few words respecting the measure which is generally employed to determine the mechanical effect produced. This is the measure of the deservedly celebrated Mr. John Smeaton, who says that "the weight of a body multiplied by the height through which it descends, while driving a machine, is the only proper measure of the power expended; and that the weight multiplied by the height through which it is uniformly raised is the only proper measure of the effect produced." Mr. Smeaton was led to the use of this

measure by his professional habits; and many who in this respect pay too great a deference to his authority, have adopted this measure as universal and preferable to any other. Taking this as a popular measure easy to recollect, and simple in its application, it undoubtedly has its uses; but in many instances it is inadequate to the purpose for which it is proposed. The late Professor Robison has some excellent observations on this subject, in the article *Machinery, Sup. Encyclopædia Britan.* where he lays down the just measure to which the scientific investigator will generally have recourse. "We take, says he, for the measure, (as it is the effect) of exerted mechanical power, the quantity of motion which it produces (or whose accumulation it prevents) by its uniform exertion during some given time. We say *uniform exertion*, not because this uniformity is necessary, but only because, if any variation of the exertion has taken place, it must be known in order to judge of the power."

A single instance may be adduced, to which the measure of Mr. Smeaton is inapplicable, and in which we must have recourse to some such measure as that mentioned by Professor Robison. Suppose that a horse while standing still sustains by means of a rope and simple fixed pulley, a mass of a hundred weight, and thus keeps it suspended at the top of a well, for the space of a minute. Neither the animal nor the weight moves, but shall we therefore say, in conformity, as it would seem, with Mr. Smeaton's measure, that there is no power expended, and no effect produced? On the contrary we know there *is* a power expended, and that the effort if sufficiently long continued would completely tire the horse. The effect which is produced is the annihilation of the simultaneous action of gravity upon the suspended mass; consequently, the effect produced is equal, and contrary to the momentum that would be generated by gravity in the

space of a minute. So that $50 \times 32\frac{1}{6} \times 112 = 216160$, is the proper representative of the power expended, as well as of the work done. Were the rope to be cut and the weight suffered to fall for a minute, the same number would likewise denote the labour of the horse in restoring it to its original place, provided that could be accomplished in an equal space of time, without the horse changing his situation.

It may not, perhaps, be entirely useless to state this matter rather more universally. To this end, let M represent any mass or body, $g = 32\frac{1}{6}$ feet, the velocity communicated to a body falling freely in the first second of time, and $t^{\cdot}$ an indefinitely small portion of any time whatever t. Then will $g\,t^{\cdot}$ be the velocity generated in the instant $t^{\cdot}$, and $M\,g\,t^{\cdot}$ the corresponding quantity of motion; this, therefore, measures the effort which must be exerted at each instant to sustain the weight, whether that effort be applied immediately, or through the intervention of a single fixed pulley. Hence it follows, that during the whole time t, the force will have consumed a quantity of motion equal to $s\,M\,g\,t^{\cdot} = M\,g\,t$: that is to say, if t denote the time at the end of which the agent is no longer able to sustain the mass M, we may regard $M\,g\,t$ as being an adequate measure of the force Q of that agent. If the agent not only prevent the mass from falling, but actually raise it with a given uniform velocity V during the whole time t, then we must add the quantity of motion MV to the former, which gives $Q = MV \times M\,g\,t = M\,(V \times g\,t.)$ And lastly, if the agent possess inertia, its mass must also be considered. Thus, in the case of a horse whose mass is H, moving along with the velocity V during the time t, and raising the mass M, we shall have $Q = (M \times H)\,V \times M\,g\,t$. And from similar principles formulæ may be investigated to represent the power of a first mover in more complicated cases.

It will after all, be proper to distinguish carefully between the quantity of power expended, and that portion of it which is *usefully* employed: but a due consideration of this would too widely extend the limits of the present communication. Indeed I ought to apologize to yourself, and the scientific part of your readers, for dwelling so long as I have done upon topics which are well known to all who are conversant in the theory of mechanics: but if those, for whose use this letter is chiefly intended, shall derive some precise information, or add to the stock of their practical knowledge, by any hints of mine, I shall not fear being heavily censured for having entered thus into minutiæ.

I am, Sir,

Your's very respectfully,

OLINTHUS GREGORY.

Royal Mil. Academy, Woolwich,
June 10*th*, 1805.

(11 *Nicholson's Journal*, *p*. 145.)

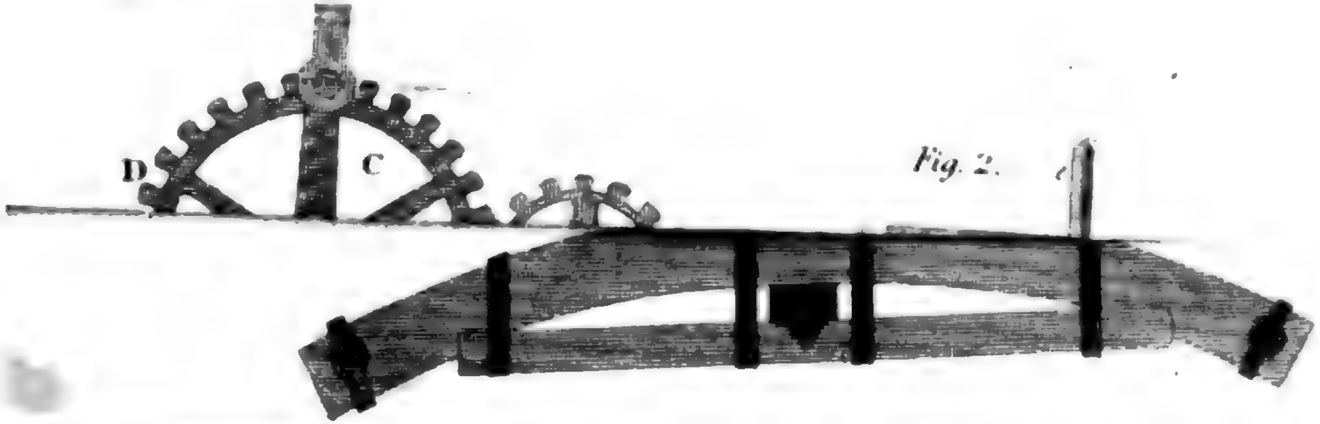
On the Construction of the Beams of Steam Engines. By Mr. J. C. HORNBLOWER. *From the Author.*

DEAR SIR,

I BEG leave through the means of your Journal, to lay before the public an account of the framed lever mentioned at the close of the article *Carpentry* in the supplement to the Enclycopedia Britannica, as it was originally designed for an engine to have been erected at Amsterdam in the year 1776, together with two others, possessing every possible advantage of levers consisting of small scantles.

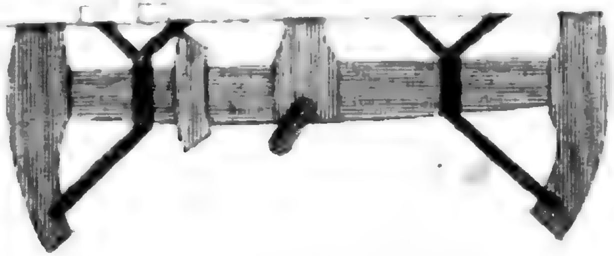
I know not by what means the lever above referred to come to be constructed with the disadvantages intimated by the writer of that article, but there is no necessity for a hole to be bored, or a bolt to be driven in any part of the framing between the arches, except for the chain stays.

Fig. 2.



Pl. 2.

Fig. 1.



The wedges *a*, *b*, Fig. 1. Plate IV. thus applied, would be an improvement, for want of which a lever of this sort in the hands of a negligent engineman had one of its joggles forced off, the shoulder of the tennon, which was morticed into the arch, not being a joint by the eighth of an inch, or more; but when it met with the arch it went no further, and continued to work for many years under a great load, and much to its disadvantage in other respects.

The length of this lever was 21 feet, the scantles were 12 inches by 6; height of the whole when put together 30 inches, and leverage on the gudgeon as 4 to 3. This last circumstance operated much against its construction, by giving additional force against the joggle at that end, but had it been framed six inches higher, I doubt not but it would have stood to this day under all its disadvantages.

The sum of the scantles is 18 by 12, area of the section 216 inches, column of water in four lifts 4800 lbs. with 440 fathoms of rods, (pump rods) which with the appendages on the other end, added to the power necessary to overcome the resistance, amount to about seven tons.

But a much simpler, and in some respects a more advantageous mode of framing is shewn at Fig. 2, and may be constructed with or without arches. This, with little variation, is the invention of a Dutch gentleman, and was applied to the load of a 52 inch cylinder (an atmospherical engine) set up with advantages, which in point of workmanship at that time was perhaps not equalled, and therefore may be said to have been fairly tried.

This engine was calculated to raise 60,000 gallons per minute, and the scantles were 18 by 12, and 12 by 8, and where such timber can be had, it is hardly to be expected to have a lever with greater advantages than this for a single stroke, and where a double stroke is required it may be doubled for that purpose, retaining all its princi-

ples and properties as in Fig. 3. which I suppose needs no explanation.

Fig. 4. is a lever constructed by an eminent engineer in Hungary some years since, which possesses a very great degree of support by the king post and iron braces, but does not, in my opinion, discover so much science as the two preceding ones. I forgot to observe, that inner arches may be attached to Fig. 1. without materially affecting its principle, if they are well let on the whole framing, and bolted to each other without passing through the scantles.

I am, Sir,

Your most obedient Servant,

J. C. HORNBLOWER.

East Row, City Road, Tuesday, May 11, 1802.

(*2 Nich. Journ.* 68.)

Letter from Davies Giddy, *Esq. M. P. describing a singular fact of the invisible emission of steam and smoke together from the chimney of a furnace; though either of them, if separately emitted, is visible as usual.*

To Mr. NICHOLSON.

SIR, *Clifton, August* 6, 1805.

TRAVELLING, and a variety of occupations, have hitherto prevented me from sending you an account of the circumstances observed by myself and others, during the working of an engine on Mr. Trevethick's construction, at Merthyn Tidwell in South Wales, and which I had the pleasure of relating to you, some time since, in Soho Square. I now transmit a statement of the facts, avoiding all comments or attempts at explanation.

Mr. Trevethick *having adapted his steam engine to the purpose of moving waggons,* contrived every accessary part as light as he possibly could, and as little inconvenient to persons who might assist, or witness an experiment. The flue for conveying off the smoke, and afford-

ing a draft, was made of rolled iron; and the steam, which wholly escapes from these machines uncondensed, was conducted into the same tube, about a foot above its insertion into the boiler; therefore many feet from the fire, and beyond the register. When the engine began to move, it was soon remarked that neither steam nor smoke were seen to issue from the flue: and when fresh coal was added, nothing more than a faint white cloud became apparent, and that only for a short time; nor were drops or mist visible any where. It was proposed, that the register should be slowly closed; and as this was done, a condensation of steam manifested itself at a small distance from the chimney, and finally appeared in the same quantity, as if it had proceeded immediately from the boiler. The experiment was then reversed. The steam was gradually confined to the boiler; when smoke became more and more visible, till it equalled in quantity and appearance that commonly produced by a similar fire: and these trials were alternated a great number of times, with unvarying success. Lastly, it became a matter of speculation, whether or in what degree the draft was affected by the admission of steam into the flue. To ascertain this, every one present looked as attentively as possible into the fire-place; while the en gine moved at the rate of a few strokes in a minute; and all agreed in declaring, that the fire brightened each time the steam obtained admission into the chimney, as the engine made its stroke.

I am, Sir,

Your very faithful humble servant,

DAVIES GIDDY.

(12 *Nicholson's Journal*, *p.* 1.)

Description of an Engine for affording mechanical power from air expanded by heat; by Sir George Cayley, *Bart.**

To Mr. NICHOLSON.

Sir, *Brompton, Sept.* 25, 1807.

I OBSERVED in your last vol. p. 368, that some experiments have been lately made in France upon air, expanded by heat, applied as a first mover for mechanical purposes. This idea, as you justly remark, is by no means new in this country; yet I have not heard that any successful experiments have been made, exclusively upon this principle, in England, though you hint that something promising has been accomplished relative to it.

The subject is of much importance, as the steam engine has hitherto proved too weighty and cumbrous for most purposes of locomotion; whereas the expansion of air seems calculated to supply a mover free from these defects. Under this impression I send you a sketch of an engine I projected upon this principle several years ago; it was made on a considerable scale at Newcastle, though I must confess without success in the result, which I attributed to the imperfect manner in which it was executed, the cylinders being made of sheet copper, and so irregular, as not to be rendered tolerably air tight by any packing of the piston. I think there can be no doubt that the scheme is practicable in some way or other; and I conceive that the form of the engine here sketched will be the basis of whatever experience may prove to be additional requisite to perfection in the apparatus of the air engine.

A and B, Plate 8 fig. 1, are two cylinders, placed one

* I extract this paper merely to give notice of the idea expressed in it. I do not think it necessary to give the plates of a machine that has not succeeded. T. C.

above another; C and D, their respective pistons connected by one rod. F is a cylinder, containing a fire in a vessel within it in such a manner, that any air passing between the upper and lower portions of it must go through the fire. This vessel also contains a long cylinder, open at the bottom and directly over the centre of the fire, for the purpose of holding coke or other fuel. This cylinder is covered at the top, and packed air tight when it has served the purpose of permitting the fire to be kindled through it: and has been filled with fuel.

The cylinder B is fitted up to answer the purpose of a double stroke forcing pump, or bellows, to drive the air into the upper portion of the vessel F, from whence it passes *downwards* through the fire for the purpose of consuming the smoke (the fresh fuel being supplied from the reservoir above) in its passage through the more completely ignited cinders below. In this act the air is expanded; and, by means of pipes from the lower portion of F, it is conveyed alternately above and below the piston of the cylinder A. In each pipe is fixed a stop cock or valve, so constructed as to open a passage to the external air, when it shuts the connection with the fire vessel. These cocks are worked by a plug frame.

From this construction it will appear evident, that whatever expansion the air receives, its pressure will operate alike upon the piston of the bellows and of the receiver; and that always in opposition to each other: Hence the power of the stroke will be in proportion to the excess of the area of the receiving piston, over that of the feeding one, multiplied by the expansive force of the contained air, and by the length of the movement.

If, when the engine is well constructed, the expansion of the air in keeping up the fire be not found sufficiently sensible, still the form of the engine is such as to admit of either inflammable gas, oil of tar, or other inflammable

matters, being injected, each stroke, upon the fire; so that all the heat generated by the united combustion may operate without waste; perhaps even a slight sprinkling of water, either upon, or round the sides of the fire, might answer the purpose. It scarcely need be observed, that a tube connected with a small forcing pump are the only things required for producing these effects.

I remain, Sir,

Your obedient servant,

GEORGE CAYLEY.

(18 *Nicholson's Journal, p.* 260.)

Summary of the rise and progress of the Steam Engine. *By the Editor.*—I have now given all the information I deem important, on the *iron manufacture*, and the *steam engine*. The references I have furnished, will enable the reader to supply the slight deficiencies of information, as they comprise every publication of any character upon the subjects discussed. The summary of the improvements gradually introduced in the theory and practice of the steam engine, and inserted in No. 2 of this volume, p. 217, was printed during my absence in Philadelphia; and unless the errata be corrected, will not in some places be intelligible: for this reason, I chuse to repeat that summary, with a few additional remarks.

1. It does not appear that the theory of the steam engine was ever clearly suggested until the Marquis of Worcester's Century of Inventions in 1663. An old historian, I do not know who, writes concerning Pope Silvester (Silvester 2d) thus: Fecit arte mechanica, orologium, et organa hydraulica, ubi, mirum in modum, per aquæ calefactæ violentiam, implet ventus emergens concavitatem barbati, et permulti foratiles tractus æreæ fistulæ modulatos clamores emittunt. 1 Athenæum, 136. I wish

the compiler had cited, by name, the author of this account: this mode of blind reference is a very silly practice.

2. The first person who appears to have reduced the theory of the Steam Engine to actual practice, was Capt. *Savary*, about 1696. He made a vacuum in a pipe whose lower end descended into water, by condensing steam thrown into a reservoir connected with the pipe; and this permitted the atmosphere to press the water upward to the usual height that will counteract or sustain the atmospheric column: he then forced it upward by the pressure of Steam upon the surface of the water in his receiver, or reservoir.

3. *Newcomen* and *Crawley*, in 1712, erected an engine wherein the piston working in a cylinder, was raised upward by the force of Steam; which being condensed by injecting water into the cylinder, a vacuum was formed, and the piston was depressed by the weight of the atmosphere on the top of it, no longer counteracted by the atmosphere underneath it.

In *Savary's* engine, there was great waste of steam by the condensation occasioned by the water on the surface whereof the steam acted: in *Newcomen's* engine, there was great loss of time and of fuel, by the cooling of the cylinder by the water injected to condense the steam: the steam also was of no further use, after having raised the piston to the required height. Hence,

4. Mr. *James Watt* of Glasgow, now of Birmingham, after much reflection and experiment, introduced the following improvements.

He condensed the steam in a vessel separate and at a distance from the cylinder; which is now no longer cooled by the injection-water, as in *Newcomen's* or the atmospheric engine.

He makes an approximation to a vacuum by pumping

out the air, which always, to a certain degree, accompanies the steam, and by its elasticity re-acts against the under side of the piston.

He keeps the outside of the working-cylinder, hot, by the intervention of steam between it and a casing.

He contrived the parallel motion, by which the piston and the upright rod attached to it and connected with the beam, preserves its perpendicularity during the stroke.

He depressed the piston by letting in steam above and upon it, instead of leaving it to descend by the pressure of the atmosphere, thus doubling the duty performed by the steam, and gaining in power and frequency of stroke.

He kept the top of the piston, hot, by means of a casing between the piston and the outward air; so that the steam let on above, is always of the same temperature with that let in below the piston.

He consumed the smoke of the fuel, by making it pass through and over the red hot coals: thereby converting the carbon and the carburetted hydrogen of the smoke into fuel; and preventing the bottom of the boiler from being covered with soot, which is a non-conductor of heat.

He supplied the boiler with the hot-injection water.

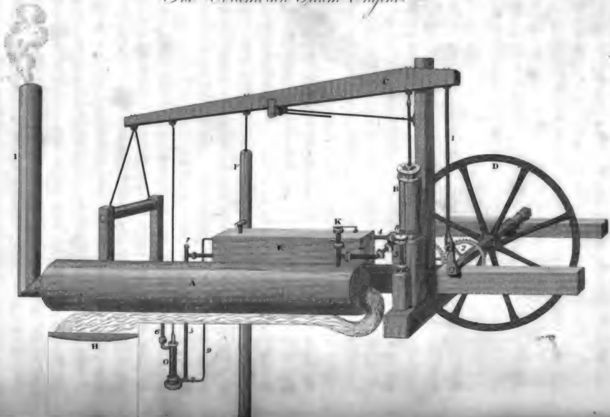
He applied two pipes or tubes inserted into the boiler at different depths; and furnished with cocks; by means of which, it can be ascertained when the boiler is too full, by its throwing out water, or too empty, by its throwing out steam.

He improved the method of letting the hot-injection water into the boiler as need required, by opening the valve with a floating stone instead of the ball-cock.

He first gave perfection to the rotatory motion by the Sun and Planet wheels connected with the fly.

He sedulously aimed at perfection in every part of the workmanship of the engine, which in his case became much superior to any antecedent engine.

The Columbian Steam Engine



Mr. *Watt* connected himself with Mr. *Matthew Boulton*, of the Soho Manufactory at Birmingham; and his son and Mr. *Boulton's* son, still carry on the business. It has been calculated, near ten years ago, that his engine has produced to the nation a saving of 75,000*l.* sterling per day: perhaps it would not be extravagant to calculate it at this moment at 25 millions a year. Mr. *Watt* was born in the latter end of 1736 or the beginning of 1737. He is, I believe, yet alive.

M. Prony who has published two large quarto volumes on hydraulic architecture, has dedicated nearly one of them to the description of *Watt's* steam engine, without having once mentioned Mr. *Watt* as the introducer of these great improvements, and indeed without even mentioning his name. He mentions the *Perriers* who in 1779 purchased from *Boulton* and *Watt*, one of these engines to supply part of the city of Paris with water: they erected it about a mile and a half from Paris on the road to Passy. One would conjecture from *Prony's* account, that the *Perriers* had the merit of constructing this engine, for neither Mr. *Watt* or Mr. *Boulton* is noticed. In the year 1792 young Mr. *Watt* and myself, went to look at *Perrier's* engine, and the person who shewed it, gave us to understand it was *Perrier's* contrivance altogether. This robbery of other people's merit is disgracefully common in that country.

The ingenuity of the English, however, was perpetually exerted in the improvement of this great national invention. I shall notice briefly, the chief improvements or proposed improvements.

Among the persons who early suggested alterations in this machine was the Reverend Mr. *Cartwright*, author of the beautiful poem of Armine and Elvira, and who has since brought to perfection, the application of the steam

engine to the whole process of weaving. His improvements consist in

5thly. A new and ingenious method of giving the necessary perpendicular motion to the piston-rod.

In condensing the steam, by expanding it in a very thin surface between hollow metal balls cooled withinside the inner one, and withoutside the outer one by cold water; so that a great surface of steam is exposed to the action of cold, as a great surface of wick in *Argand's* lamp is exposed to an inside and outside current of air.

He attempted to save much trouble usually necessary in packing the piston, by fitting accurately a metal piston to the cylinder, by means of springs that keep the piston in close contact with the inner side of the working cylinder.

As he pumps up all the steam thus condensed, into the boiler—and as this steam is condensed without intermixing with the cold water used for condensation, his principle admits of the use of ardent spirits, if this liquid should at any time or for any reason be preferred.

I do not know whether Mr. *Cartwright's* engines are much in use. An account and drawing of it, I have already given; another engraving of it may be found in 1 Tilloch's Philos. Mag. 1.

6thly. Mr. *Hornblower's* improvements do not seem to consist in the adoption of any new principle, for reasons stated by Professor *Robison*, in the article steam engine in the Edinburgh Encyclopædia, p. 771, (which with the supplement ought to be perused) but in the methods used to make his collars air tight—in the structure of his condensing vessel, and in the framing of his beams. A plate of *Hornblower's* engine is given by Professor *Robison* in that article, and by Dr. *Gregory* in the second volume of his Mechanics.

7thly. Mr. *Sadler's* improvements consist

In his working without a lever and beam. Also Part of the steam previous to condensation is employed a second time in another cylinder, the piston of which is depressed by the atmosphere. In this second application it performs the office of an air pump, and adds to the total force of the machine.

Mr. *Hornblower*, as may be seen by his patent which I have inserted, early proposed the use of the steam in a second cylinder previous to condensation; which has also been adopted by Mr. *Woolf*. I do not find that any engineer, has superceded the use of the beam previous to Mr. *Sadler*. But whether his engine is in vogue or not, I cannot say. There is no beam to the portable engine of Mr. *Clegg*, of which I have given a plate. The method of giving rotatory motion adopted by Messrs. *Long* and *Hauto*, of Germantown, if it succeeds will also supercede the necessity of the beam. Their other principle, of giving motion by the pressure of a column of water confined in a pipe, has been used in France about the year 1731, and afterward in Cornwall: since that by Mr. *R. Trevethick*, at the Druid copper mine near Truro, in Cornwall; and has been applied to packing goods by Mr. *Brama*, of London. See 1 Nich. Jour. 8vo. p. 161.

8thly. Mr. *R. Trevethick's* steam engine, seems constructed on the plan of using steam at a very high temperature, and letting it escape without condensation. The accident that happened to one of his engines, and of which I have given an account, has brought them into disrepute, to a certain degree, but I see no objection to the principle, which may be applied with perfect safety if reasonable caution be used in the construction of the apparatus, and in working it.

9thly. Portable steam engines have lately become fashionable. *Watt* and *Boulton* make them of all sizes:

Clegg's and *Murray's* appear to me entitled to consideration.

10thly. But Mr. *Woolf* of London, seems to have gone farther in improving this machine than any other person, since the patent of *Boulton* and *Watt*.

He has more accurately than his predecessors, ascertained the law of the expansion of steam, by a volume for each pound per square inch on the safety-valve. Hence,

He can use his steam at a higher temperature than it is used in the common engine of *Boulton* and *Watt*, and more under the command of accurate calculation.

He uses it twice over in separate cylinders; though it seems to me, that there is nothing novel in this part of his process.

He applies heat to the hot steam in the second cylinder: using oils, or metalline substances of easy fusibility as the mean of communicating and preserving heat to the steam: this part of his patent seems to me original; though the same idea was communicated by Chancellor *Livingston* to Dr. *Priestley*, but whether previous or subsequent to *Woolf's* patent I cannot now say.

He has contrived a safety-valve, and a method of measuring the elastic force of steam, which I have thought deserving of being communicated by a plate.

He has superceded the necessity of such frequent packings of the piston, by a contrivance of which I have given a general account, referring to the publication where a plate of it can be found.

He has given a substitute for a fly wheel, that in certain situations will doubtless be useful; but I have thought it sufficient to refer to the description, 6 Nichols. Jour. p. 218.

He has lately introduced a new principle by making the steam press in the first instance on a body of oil, which re-acts, as I understand it, against the bottom of

the piston; and when the force of the steam is taken off by condensation, the piston descends forcing the oil back into its former situation, and so on alternately. The oil of course is kept hot. In this way any escape of air among the steam to re-act against the motion of the piston is doubtless prevented: but I have not been able to procure the specification at length, and therefore cannot pretend to accuracy concerning it.

His boilers are of a new, and, as I think, a greatly improved form. Of this improvement I have given a description and a plate.

All these improvements are open to our own engineers. The time is now come, when a *civil-engineer* will be in general demand, and will meet with the success in point of fortune, and the respect in point of situation in society, which the able men of this description are sure to find in Great Britain. The three great requisites of a civil engineer, are first a profound knowledge of mathematics, and an habitual facility of applying mathematical principles and calculations to mechanics and machinery. Secondly, a full knowledge of the modern science of chemistry. Thirdly, an habitual facility in drawing and designing with neatness and accuracy. To these should be added, actual observation and study of the principal machines in use and their application.

I have given Mr. *Oliver Evans's* description of his steam engine, but for want of his patent-specification, I am not able to point out precisely, what part of it he claims as his peculiar invention. I shall be glad to insert such a precise specification of his claim when I am enabled so to do.

For the present, I conclude the article of STEAM ENGINES.

ON THE ART AND METHOD OF BRICK-MAKING.

THE manufacture of bricks was never carried on so extensively as at present, through the rage, not only for building but for improvement in the metropolis, and throughout the suburbs and every town in the united kingdom. Amongst most articles of British manufacture we see a gradual improvement upon the methods and systems of former times, and the principles of building under the architects of the present day are brought to a state of perfection not to be rivalled by future ages, but, strange as it may appear, the texture and durability of the most essential requisite for building, bricks, instead of being in a state of improvement, according to the science of building, are in a retrograde state, and far inferior to those of ancient times.

Brick-making, of late years, has furnished a very considerable branch of trade around the metropolis, not only very productive to the land-owners, but it has produced an extensive help to the revenue of the country; yet much of the brick now in use will hardly wear out a twenty-one years lease. That there must be something radically wrong in the present system of manufacturing the brick earth is very evident, as we have the same means of procuring brick earth equally fit for the purpose as formerly. With this impression, at the instigation of one of our correspondents connected with building, we think it may be beneficial to those concerned to lay before them the theory and practice of brick-making, as drawn up some time since by Mr. James Malcom.

He observes, that the manufacture of them is of the utmost importance to the community, inasmuch as the value and comfort of our dwellings must depend in a great measure on the quality of the materials with which

they are constructed; and bricks form no inconsiderable part of them. I say it is material to us, because if the bricks with which our houses are now almost uniformly built are in quality defective, and if the timber be of a similar description, we ought not to place much dependance on the solidity of the edifice.

The soil on the Surrey side of London is only calculated for certain sorts of bricks, and these, it must be confessed, are inferior to those made in Middlesex. We have neither depth, nor that pure medium argillaceous substance, which is so essential to form the perfect brick; we have either too much silex, or, to speak the common language, too much flinty sand; and the stones are too abundant, large, and too near the surface, which cause the bricks to vitrify, and thereby their colour and quality is injured; or we have a portion of calcareous matter, which causes the bricks, after being taken from the clamps, insensibly to moulder away by exposure to the air or to moisture; and where it is argillaceous, as in Camberwell and Dulwich parishes, it is to that extreme, as to be impossible to be moulded without the assistance of some adventitious combinations. What those combinations are, which form the several varieties of bricks manufactured in the county, together with some cursory remarks, will form the subject of this essay.

Synopsis.—At Kennington, at Walworth, at Camberwell, and in Battersea parishes, we have manufactories of bricks to a much greater extent probably than all the rest of the county united. In analyzing the earth which has been generally used, I followed the plan of the learned bishop of Llandaff. Eight ounces of earth taken out of the pit as they were digging it (Mr. Fentiman's), and moulding it into an oblong square, I placed on the hob of a Bath stove in my study, where a constant fire was kept for seven days. I then weighed it, and found it had lost one

ounce and three quarters. I did the same by that at Walworth, and during the same time it lost nearly two ounces; that at Camberwell lost in the same time three ounces four pennyweights; that at Battersea, two ounces six pennyweights. In the solution of these earths, after having exposed them to the muriatic and the acetous acid, it was evident that, besides a large portion of pure argil which the earth at Camberwell contained, there were not less than eighteen parts in one hundred of iron, a small portion of silex, and about six parts in one hundred of calcareous earth: and it will be seen, that the quantity of water which the clay and the calcareous earth held was considerable; from this I infer, that although the colour of the bricks, and the difficulty and consequent expence in moulding the latter was greatly against the manufacturer, yet, as to the materials, they were far superior to the others in an essential property, I mean durability. Those at Kennington and Walworth were nearly similar in their products, the latter possessing the most argil; and those at Battersea still more; the earth therefore imbibing more moisture, consequently loses more in burning.

The moulds used in making every sort of brick for building purposes are ten inches in length, and five in breadth; and the bricks when burned usually measure nine inches in length and four and one-half in breadth, so that the clamp shrinks about one inch in ten. But the degree of contraction (as we have before seen) which clay undergoes in being burned, does not absolutely depend upon the purity of the clay; for as some clay imbibes more moisture than others, if that which imbibes the most is not exposed a much longer time to the frost to divide and separate its particles, and to the heat of the sun to exhale its moisture, than that which imbibes less and is a shorter time exposed, it follows, that while the one

will be reduced one inch, the other may lose two or more. Again, the heat of the kiln or clamp, and the situation of the bricks as to heat, will vary the diminution of the subject to be burnt. It is of consequence, therefore, in the making of sound hard bricks, that the clay should be dug two or three years before it is used, in order that it may be pulverized; and the oftener it is turned and incorporated, the better will be the bricks. The earth should have sufficient time to mellow, ferment, or digest, which will render it more apt and fit to temper; and this operation of treading and tempering ought to be performed more than doubly what is usual, because the goodness of the bricks wholly depend upon the well performance of its first preparation, since the earth in itself before it is wrought, is generally brittle, full of extraneous matter, which requires to be removed, and as it were without unity and stability; but by adding small quantities of water by degrees to it, and working and incorporating it together, the several parts of it are opened, and by being thus exposed to the atmosphere a tough gluey substance is formed, which, without such tempering, treading and beating, could not have been produced. I can only compare this preparation of the soil to that of making bread. When there is a due quantity of water put to the flour, and well wrought up together, such bread becomes not only smooth and firm, without having eyes or being subject to crumbling, but it, eats sweeter and mellower, and becomes easier of digestion, affording far better nourishment than such as is over-watered, heavy, and not sufficiently tempered; provided the other operations, which belong to the making of good bread, such as baking, &c. be properly performed.

Bricks thus tempered become solid, smooth, hard, and durable; and one brick thus made takes up nearly as much earth as a brick and a half made in the common

way; but these are light, full of cracks, and spongy, owing to the want of due working and management; and the mixing of ashes which is now the uniform practice about London, and light sandy earth which is usually practised in the country, to make them work easy, and with greater dispatch, serves also to save coals or wood in the burning them.

The excellency of bricks consists chiefly in the first and last operation; for bricks made of good earth, and well tempered, become solid and ponderous, and therefore will take up a longer time in drying and burning than our common bricks seem to require. It is also to be observed that the well drying of bricks, before they are burned, prevents cracking and crumbling in their burning; for when the bricks are too wet, the parts are prevented from adhering together. The best way of ordering the fire is, to make it gentle at first, and increase it by degrees as the bricks grow harder. If those several operations were properly and duly attended to we should not see such immense waste, and so great a profusion of unburnt and half burnt bricks, called place bricks, as we constantly find on the outsides of our modern clamps. For want of due precaution the fire never reaches them in an equable degree, and therefore they ought to be totally disregarded and laid aside; but modern ingenuity, and the tricks of the builders, have found out a mode of using them less objectionable to be sure than if they were consigned to the outside walls, though properly they are not fit to be used any where. It is necessary that the public should be informed, that these place bricks are now made use of in the inside walls of houses of every denomination, from the hut to the palace; and that they are soft, subject to very quick-decay, and wherever wet can at all get to them, they moulder away with great rapidity; nor is this the only objection to them; they are subject to be acted upon

by every change of the weather, so that the walls become damp, and the plastering discoloured, causing the bond timbers and plates to rot; and for want of equal solidity with the external bricks the walls crack, the timbers swag, because the bearing on them cannot be then any where equally poised.

The dampness which so often affects the inside walls is attempted to be palliated, or removed, by the introduction of what is called battening, whereby an opening or cavity is left between the brick-work or plastering; but whoever has attentively observed the result of this invention, which in very many instances has fallen to my lot to notice, will see that the damp arising from these bricks engenders mould, and is visible on the frame of the wood used in the battening; this mould is no doubt the secondary cause of the dry rot, since the origin must be in the bricks themselves.

That this is the case may be deduced from this fact, that wherever a quantity of those bricks is heaped up together for any length of time, they will upon separation be found to have their bases covered with a fine white net-work, especially those which are nearest the bottom. Hard burnt sound bricks never have this net-work grow upon them, let them lay as long as they may in any situation. This net-work then is the plantulæ of mould. The origin and increase of mould is nearly in proportion to the heat of the atmosphere; its appearance and vegetation are never more sudden than during the summer, and the reason seems to be, that the heat of the weather necessarily draws out the redundant moisture from the bricks, for want of a due circulation of air. This moisture attaches itself to the outside of the bricks, and there remains, the heat not being sufficient to dry it up, but enough perhaps to produce a degree of warmth; it enters into a slow but certain process of fermentation; and, pass-

ing through a state of acidity to putrefaction, is of itself sufficient to engender mould. Sometimes it is very long before mould is produced on particular substances, either from the absence of the seed, or the substance not being well adapted for its vegetation; while in others, the seed has been known to vegetate in three hours. The mould from being first white turns yellowish, and at last blackens. As it approaches a state of maturity, a kind of black dust falls from it, which is the seed of the plantulæ; a quantity of this dust constitutes the powder, which blackens the hand when touched. As this dust and seed is so fine and infinite, it spreads with a rapidity equal to the state and condition of the substances which may be fit to receive it, and hence may attack a whole building, and become the means of endangering and eventually destroying the most superb edifice.

Another fact will confirm this reasoning. In pulling down the most ancient houses not an atom of dry rot has been visible, but merely a decay in the timbers occasioned by age, because the bricks inside and out were alike hard and sound: but where modern ones have been erected on the old sites, a very few years have been sufficient to prove, that symptoms of dry rot have manifested themselves in the basement, from the great degree of humidity which prevails there.

If such bricks therefore are not timely removed, all the art of man cannot prevent the effects of the dry rot: it is the same with certain sorts of stone, which are always damp, be the weather what it may, and there the dry rot makes the greater havock.

Besides the bricks made at the places before-mentioned, there are some made at Tooting, of common stocks, at Mr. Brodie's; at Croydon, by Mr. Cooper; some very good white bricks, and geometrical tiles, at Reigate, by Mrs. Lucock; at Send Turnpike, by Mr. Daws; at

Brook, in the parish of Witley, by Mr. Mitchell; at Wilderwick, by Mr. Avery. The common computation is, that every acre will yield one million of bricks in every foot in depth, which also includes ashes that are usually mixed with it. In general our fields are shallow with a bottom of gravel, yet I think they will average nearly five feet, though I believe we have none that will run ten, twelve, or more feet as about Kingsland, at least such is my information, as well as observation.

There is a duty imposed on bricks by three acts of parliament, of five shillings for every one thousand of bricks payable by the maker, who is allowed ten for every one hundred when charged in the field, before burned, in compensation for all waste, loss, or damages; and the duty must be paid in six weeks. Also,

	s.	*d.*
For every 1000 plain tiles - - -	4	10
For every 1000 pan tiles, or ridge tiles -	12	10
For every 100 paving tiles, not exceeding ten inches square - - - - -	2	5
If exceeding ten inches, an additional duty of	4	10
For every 1000 tiles, other than the above, by whatever name known - - -	4	10

The price is as under, (1810).

	s. *s.*
Best washed malm or marl stock	50 to 60 per 1000
Seconds - - - -	40 to 50
Picked grey stocks - -	30 to 36
Common ditto - -	26 to 30
Place ditto - - -	21 to 24
White bricks - -	64
White geometrical tiles - -	64
Red tiles - - -	40

Manufacture.—Bricks are made by the thousand, as the most satisfactory mode between master and man;

and a handy man can mould in one day, viz. from five in the morning until eight at night, five thousand. To assist him in the preparation of the soil, &c. from the heap (which is usually dug after the season for brick-making is over and laid up) there is generally a gang consisting of six persons; one man (but sometimes a woman) tempers and prepares the soil, which is done with a hoe made long, in the shape of a mattock, a shovel, a scoop, a thick plank or board, and a cuckhold; with the hoe he pulls down the soil from the great heap, which is chopped backwards with the shovel, to turn it as often as may be necessary, to mix and thoroughly incorporate the ashes and soil together (because it is to be understood that at the time the soil is dug out, and made into this heap, a layer of coal ashes is alternately placed between a layer of soil, as often and in such quantities in each layer as the quality of the soil and other circumstances may make necessary.) The scoop is used to throw water over this portion that is pulled down with the hoe, in order that it may become more and more in a tempering state, more soft and ductile; and with the board he kneads it together, over which a certain quantity of sand is thrown, and it is then covered with pieces of sacking or matting to keep the sun and air from it. A boy of ten or twelve years of age scoops or cuts off a slice with an instrument or shovel having a short handle, and the blade of it made concave, called a cuckhold, which he brings on his arms to the moulding table, which is placed under a moveable shed, upon which a girl of the same age rolls out a lump somewhat bigger than will fit the mould, the table having been previously strewed with sand. The moulder, after dipping his mould into dry sand placed at one corner of his table, throws the lump prepared by the girl into the mould, and with a flat smooth stick about eight inches long, previously dipped in a pan

of water, strikes off the surplus soil; he then immediately turns out the contents of the mould upon a stand or board of the same size with the brick. A boy takes it from thence, and places it on a light barrow, with a lattice-work frame fixed over the frame of a long barrow, at about three feet high above the wheel, and reduced to about eighteen inches in height towards the handles, forming an inclined plane. The new made bricks are placed on this latticed frame, and over them sand is thrown in sufficient quantities to prevent their adhering to each other, as well as to prevent, in a certain degree, their cracking in drying while on the hacks. A girl wheels the barrow to the hacks, and places them with great regularity and dispatch one above the other, a little diagonally, in order to give a free passage to the air. Each hack is made wide enough for two bricks, to be placed edgeways across, with a passage between the heads of each brick; they are usually made eight bricks high, the bottom bricks at the end of each hack are usually old ones.

In showery weather, wheat or rye straw is carefully laid over the bricks that are drying on these hacks, to keep them as free from wet as possible: for the brick-makers do not here, as in places more distant from the metropolis, go to the expense of roofed coverings, or long sheds, which from the extent of one of these fields would be impossible.

If the weather is tolerably fine, a few days is sufficient to make them dry enough to be turned, which is done by resetting them more open, and turning them; and six or eight days more are required before they are fit to be put into the clamp, for kilns are not in use in this part of the county. When sufficiently dry, the clamp-maker levels the ground, generally at one end of the range of hacks nearly centrical, making the foundation of the in-

tended clamp somewhat higher than the surrounding ground: and with place bricks, if they have any unsold, or otherwise with the driest of those just made, makes a foundation of an oblong form, beginning with the flue, which is nearly a brick wide, and running straight through the clamp. In this flue dry bavins, coals, and cinders (vulgarly called breese) are laid and pressed in close, in order that the interstices between wood and coal may be properly filled up. On the sides of the flue the bricks are placed diagonally about one inch asunder, and between each layer of bricks three or four inches of breese are strewed, and in this manner they build tier upon tier as high as the clamp is meant to be; never omitting between each layer, as well as between each brick, that is placed diagonally, to put a due portion of breese. When they have made the clamp about six feet long, another flue is made similar in every respect to the preceding, to the extent of the size of the intended clamp; provided only that the bricks are meant to be burnt off quick, which they will be in about twenty-one or thirty days, according as the weather may suit. But if there is no immediate hurry for the bricks, the flues are placed at about nine feet asunder, and the clamp left to burn off slowly.. When fire is set to the clamp, and it burns well (the ash-hole being placed at the west end generally) the mouths are stopped with brick, and clay laid against them; the outsides of the clamps are plastered with clay if the weather is at all precarious, or the fire burns furiously; and to the end against which addition is made to the clamp, skreens made of reeds worked into frames about six feet high, and sufficiently wide to be moved about with ease, are placed to keep off the weather, and against any particular side where wet is most prevalent. On the top of the clamp a thick layer of breese is uniformly laid.

This is the mode of manufacturing the common grey stocks for walls and common buildings; but some brick-makers, in order to mix the soil and ashes more regularly, perform it with a machine, called a clay-mill, which a horse turns round. This machine consists of a tub or tun fixed to the ground, in which is placed perpendicularly an instrument resembling a worm or screw; the soil being put in at top is worked down by the rotary motion of the worm, and is forced out at a hole made on the side near the bottom of the tub. A man supplies the tub with fresh soil, properly moistened, while the person who supplies the moulder keeps removing that which is thus prepared, or pressed out.

Washed malms, or more properly marls, are made with still greater attention: a circular walled recess is built about four feet deep and from three to four feet wide, paved at bottom, and from ten to twelve feet diameter, having a horse-wheel placed in the centre; the ground is raised all round it, and a platform made upon a level with the top of the recess. On this platform the horse walks, a pump is fixed into a well, as near to the platform as may be, to supply the recess with water as often as occasion may require. A harrow made to fit the recess, and thick set with long iron teeth, well loaded, is chained to the traces of the horse, who drags this after him; a man wheels a barrow full of soil previously prepared in a heap the same as for the common stocks, and shoots it regularly round the recess, he then pumps a certain quantity of water, which, by means of troughs or shoots, runs on it, and sets the horse in motion. The harrow being loaded accordingly, forces its way into the soil, admits the water into it, and by thus tearing and separating it, mixes the ingredients at the same time that it gives an opportunity for stones and other ponderous substances to subside to the bottom. The man keeps supplying it

with fresh soil and water until there is a sufficient body in the recess. On one side, but as near to the recess as possible, the ground is made smooth, and dug out about eighteen inches or two feet deep into a hollow square; and the soil now becomes paste, and being thereby sufficiently washed, purified, and fluid, troughs are placed from the recess to this hollow ground, and it is ladled out with scoops or shovels into the troughs, carefully leaving the sediment at the bottom of the recess to be afterwards thrown out on the sides of it, together with stones, bones, &c. Over this hollow square or pit the fluid soil diffuses itself, where it settles of an equal thickness, and remains until wanted for use, the superfluous water being either evaporated or drained from it, by its being exposed for a certain length of time in so thin a body. When they have got a sufficient quantity of washed earth in this pit, another is made alongside of it, and so they proceed until they have got as much thus prepared as they are likely to want during the season.

The clamps for burning these better sort of bricks are individually the same with the others, but greater care is taken in not overheating the kiln, but in causing it to burn moderately, as equably and as diffusively at the same time as possible.

In the country, bricks are always burnt in kilns, whereby less waste arises, less fuel is consumed, and the bricks are sooner burnt. The bricks are first set or placed in it, and then the kiln being covered with pieces of bricks or tiles, they put in some wood to dry them with a gentle fire: and this they continue until the bricks are pretty dry, which takes up two or three days, which is known by the smoke turning from a darkish colour to a transparent smoke; they then leave off putting in wood, and proceed to make ready for burning, which is performed by putting in brush, furze, spray, heath, brake, or fern fag-

gots, according to the scarcity or plenty of some of those articles in the neighbourhood. But before they put in any faggots they dam up the mouth or mouths of the kiln with pieces of bricks, which is called in some places shinlog, piled one upon another, and close it up with wet brick earth.

The shinlog they make so high that there is but just room above it to thrust in a faggot; they then proceed to put in more faggots, till the kiln and its arches look white, and the fire appears at the top of the kiln; upon which they slacken the fire for an hour, and let all cool by degress. This they continue to do alternately, heatening and slackening till the bricks be thoroughly burnt, which is usually effected in forty-eight hours. One of these kilns will burn twenty thousand bricks, and is usually thirteen feet long, by ten feet six inches in depth, and the height about twelve feet. The walls are carried up something out of the perpendicular at top, and inclining towards each other, so that the area at the top is not more than one hundred and fourteen square feet; the thickness of the walls are one foot two inches.

The bricks are set on flat arches, having holes left in them something like lattice work.

Goldham observes that bricks will have double the strength if, after one burning, they be steeped in water and burnt afresh.*

As every man who has occasion to use bricks, whether on his own estate, or on that of his landlord, cannot but be sensible of the great value of a perfectly dry house; and as I think I have shewn that it is impossible a house can be dry if bricks are used which are insufficiently burnt, such as the place bricks I have before described, he will do well to consider whether it will not be more advantageous to him in the end, to make use of no other than the

* Common *earthen* ware, can be converted into *stone* ware, by reburning. T. C.

very best hard sound bricks, be the colour of them what they may, and be the cost what it will. Such bricks are easily known by their sound, and by their striking fire with steel. It will be found that, besides the comfort and firmness of the building, they will be cheaper than place bricks, together with the expense of battening the walls.

In the interior of the country tiles are almost uniformly used for roofs of houses, and in some instances on barns; but between Dorking and Horsham a heavy but very durable sort of slate stone is used. Nearer London either Welch or Westmoreland prevail. As there are many persons who give the preference to tiles, it may not be amiss to know the result of a curious experiment on that subject as related by the Bishop of Llandaff.

"That sort of slate, other circumstances being the same, is esteemed the best which imbibes the least water; for the imbibed water not only increases the weight of the covering, but in frosty weather, being converted into ice it swells and shivers the slate. This effect of frost is very sensible in tiled houses, but it is scarcely felt in slated ones; for good slate imbibes but little water; and when tiles are well glazed they are rendered, in some measure, with respect to this point, similar to slate. I took a piece of Westmoreland slate, and a piece of common tile, and weighed each of them carefully; the surface of each was about thirty square inches; both the pieces were immersed in water for ten minutes, and then taken out and weighed as soon as they had ceased to drip; the tile had imbibed above a seventh part of its weight of water; and the slate had not imbibed a two-hundredth part of its weight; indeed the wetting of the slate was merely superficial. I placed both the wet pieces before the fire; in a quarter of an hour the slate was become quite dry, and of the same weight it had before it was put into the water; but the tile had lost only about twelve grains of the water it

had imbibed, which was, as near as could be expected, the very same quantity which had been spread over its surface; for it was the quantity which had been imbibed by the slate, the surface of which was equal to that of the tile; the tile was left to dry in a room heated to sixty degrees, and it did not lose all the water it had imbibed in less than six days."

The finest sort of blue slate is sold at Kendal, for 3*s.* 6*d.* per load, which comes to 1*l.* 15*s.* per ton, the load weighing two hundred weight. The coarsest may be had for 2*s.* 4*d.* a load, or 1*l.* 3*s.* 4*d.* per ton. Thirteen loads of the finest sort will cover forty-two square yards of roof, and eighteen loads of the coarsest will cover the same space; so that there is half a ton less weight put upon forty-two square yards of roof when the finest slate is used than if it was covered with the coarsest kind, and the difference of the expense of the material is only 3*s.* 6*d.* To balance in some measure the advantage arising from the lightness of the finest slate, it must be remarked that it owes its lightness, not so much to any diversity in the component parts of the stone from which it is split, as to the thinness to which the workmen reduce it; and it is not able to resist violent winds so well as that which is heavier.

A common Cambridge tile weighed thirty-seven ounces: they use at a medium seven hundred tiles for covering one hundred square feet, or about two and a half tons of tile to forty-two square yards. Hence, without including the weight of what is used in lapping over, &c. when a building is covered with copper or lead, it will be seen that forty-two square yards of building will be covered by

Zinc about - - -	1 cwt.
Copper - - -	4
Fine slate - - -	26
Lead - - - -	27

Coarser slate - -	36
Tiles - - - -	54

From the foregoing statement it is evident, that we are obliged to make our plates and rafters of the roof so much stouter and heavier than there is any occasion to do for slates, even the coarser sort; and consequently this increased strength in the timber must add to the expense of the roof, supposing that the same thickness of wall be sufficient."

Brick-Making.—I add a few remarks, the result of my own observation, which may furnish some notions of the value of brick-earth.

When my father died about 1789, he owned forty acres of land at Kentish town, then two miles from the turnpike of Tottenham Court Road, London. It is now built over. He had let out four acres of that land containing brick earth, at a price then considered greatly too cheap: viz. one hundred pound sterling per acre for the brick earth: the brick-maker paying *5l.* sterling per acre for all the rest of the field that he occupied in brick-making; and being bound to fill up the holes or excavations from whence the brick earth was taken, level with the rest of the field, within one twelve month after the brick earth was exhausted. The rubbish for this purpose was usually procured from old buildings pulled down and repaired in London, brought as back loading.

The bricks made there, were *place bricks* and *gray stocks.* The place bricks being the outside bricks of the kiln, inferior, ill-burnt, soft, and used for the inside of walls. The grey stocks, being the bricks used about London, for common front-work. The colour a reddish brown.

Malm-Stocks, used for arches, were made partly near Brompton, and partly in Norfolk, of a finer kind of clay previously washed to separate the large particles of stone

or sand; and when burnt, were of a whitish colour. They were easily ground down to the required dimensions for the arch. The term *malm*, is a corruption of the old word *malin* or *marle*.

By act of parliament of 17 G. 3. ch. 4. all bricks made for sale, shall, when burned, be not less than 8 inches and a half long, 2 inches and a half thick, and four inches wide. A well burnt brick of statuteable size will weigh about 9lb.

The process of brick-making is tolerably well detailed in the preceding pages. The brick earth is thrown up in the fall of the year to mellow through the frost of the winter. It is then (in spring) worked up by labourers upon a levelled earthen floor, into a well mixed uniform moist mass. Each layer of the brick earth of about six inches thick is covered with a thin layer of *breeze*, or sifted ashes. This should be explained.

In London, where nothing but coal is used, and where the small Newcastle coal, that gives out comparatively little flame, but cakes or cements into a solid cinder, is usually preferred, the ashes under the grate contain a great deal, not only of the coak of coal, but also of the small coal itself, that in stirring the fire, passes through. The scavengers, who are also frequently brick-makers, usually contract to clean the streets, and take away the ashes from each house as often as required; this contract is by the parish. I can well remember when the parish of St. James, Westminster, paid the scavengers 700*l.* sterling annually for this service, and in the course of five years, received 1200*l.* sterling for the privilege. These ashes being sifted, the finer parts are mixed as above noticed with the brick earth, and the coarser parts are used as fuel to burn the clamp. The fine ashes and coal dust thus mixed with the brick, certainly serves to assist its being *thoroughly* burned.

When the contractor, found the moulds, sand for moulding, the breeze for mixing and burning, he could get all the labour performed from moulding the brick, to delivering it well burnt in the clamp for 11*s.* 6*d.* sterling per thousand. The bricks so made, he delivered at any reasonable distance in London for 25*s.* 6*d.* sterling per thousand, he paying a duty also of 2*s.* 6*d.* per thousand.

Bricks made in a close conical kiln, are much better than in an open clamp, and the saving of waste will in time pay for the kiln. In this country, the faults are, 1st. The earth contains too much stony matter, generally: 2dly. The drying in the air, the skintling, is not continued long enough: 3dly. The bricks are seldom thoroughly burnt to the centre, for want of the admixture of breeze.

The profit upon a thousand bricks was very great, and would well justify much more than 100*l.* sterling per acre for good brick earth. A cube yard of good brick earth, I think, would make about 500 bricks when well worked and mixed.

Plain tiles and pan tiles, usually made of a stiffer and more ochry clay, are not used with us. I have seen a substitute used in England, which I think would well answer here: viz. a kind of tile about nine inches by four inches, made of coarse pasteboard about one fourth of an inch or one half of an inch thick, and when fully impregnated with glue, covered with fine sifted sand. This would be light, impervious to moisture if a small quantity of wax were melted in the glue, and not easily set on fire, or rather not capable of being burnt. T. C.

METHOD OF MANUFACTURING ISINGLASS.

THE following paper was formerly published by Dr. Mease, in his Archives. I think proper to publish it also; for Isinglass at three dollars a pound is a sufficient inducement to find a substitute, which, in my opinion, may be found in almost any fish. It is a great pity that fish-soup should be so little used in cookery, so excellent as it is. A glue having many properties of isinglass, I have made from the dried skin of Eels, from the heads of Cat-fish, from the heads of Shad thrown away, from the Susquehanna Salmon or Bass, and from Perch. I do not know how isinglass dissolved, differs from any common fish gelly in its chemical qualities, but it is more tasteless, and therefore for some purposes more eligible. T. C.

Method of Manufacturing Isinglass.—While isinglass is such an essential in a variety of British manufactures and preparations, and for which we are indebted chiefly to importation, the following account of the method of making it, will not only be entertaining, but furnish some useful hints for British ingenuity, in procuring a substitute equal to that imported from Russia —it is taken from an account published in the 63d vol. of the Philosophical Transactions, by Humphrey Jackson, Esq.

The secret of isinglass rested a long time solely with the Russians, and made from the fish *Huso*, or isinglass sturgeon; and its name in Greek signifies fish-glue, viz. Ichthyocolla. All authors who have hitherto delivered processes for making fish-glue, or isinglass, have greatly mistaken both its constituent matter and preparation. To prove this assertion, it may not be improper to recite what a writer of the name of Pomet says on the subject, as he appears to be the principal author, whom the rest have

copied. After describing the fish, he says, as to the manner of making the isinglass, the sinewy parts of the fish are boiled in water till all of them be dissolved that will dissolve, then the gluey liquor is strained and set to cool. Being cold, the fat is carefully taken off, and the liquor itself is boiled to a juicy consistency, then cut to pieces and made into a twist, bent in form of a crescent, as commonly sold, then hung upon a string and carefully dried. From this account it might rationally be concluded that every species of fish, which contained gelatinous principles, would yield isinglass; and this parity of reasoning seems to have given rise to the hasty conclusion of those who strenuously search for the extraction of isinglass from sturgeon, but as that fish is easily procurable, the negligence of ascertaining the fact, by experiment, seems inexcusable. In my first attempt to discover the constituent parts and manufacture of isinglass, relying too much upon the authority of some chemical authors, whose veracity I had experienced in many instances, I found myself constantly disappointed. Glue, not Isinglass, was the result of every process; and although in the same view, a journey to Russia proved fruitless, yet a steady perseverance in the research proved not only successful as to this object, but in the pursuit to discover, resinous matter plentifully procurable in the British fisheries, which has been found by ample experience to answer similar purposes. It is now no longer a secret that our lakes and rivers of North America are stocked with immense quantities of fish, said to be of the same species with those in Muscovy, and yielding the finest isinglass; the fisheries whereof, under due encouragement, would doubtless supply all Europe with this valuable article.

No artificial heat is necessary to the production of isinglass; neither is the matter dissolved for this purpose, for as the continuity of its fibres would be destroyed by

solution, the mass would become brittle in drying, and snap short asunder, which is always the case with glue, but never with isinglass; the latter indeed may be resolved into glue with boiling water; but its fibrous composition would be found impracticable afterwards, and a fibrous texture is one of the most distinguishing characteristics of genuine isinglass. A due consideration, that an imperfect solution of isinglass, called *Finings* by the brewers, possessed a peculiar property of clarifying malt liquors, induced me to attempt its analysis in cold subacid menstruums. One ounce and a half of good isinglass, steeped a few days in a gallon of stale beer, was converted into good finings of a remarkably thick consistence. The same quantity of glue, under similar treatment, yielded only a mucilaginous liquor, resembling diluted gum-water, which instead of clarifying beer, increased both its tenacity and turbidness, and communicated other properties in no respect corresponding with those of genuine finings. On commixing three spoonfuls of the solution of isinglass with one gallon of malt liquor in a tall cylindrical glass, a vast number of curdly masses became presently formed by the reciprocal attraction of the particles of isinglass and the feculencies of the beer, which increasing in magnitude and specific gravity, arranged themselves accordingly, and fell in a combined state to the bottom through the well known laws of gravitation; for, in this case there is no elective attraction, as some have imagined, which bears the least affinity with what frequently occurs in chemical decompositions.

If what is commercially termed *long* and *short stapled isinglass* be steeped a few hours in fair cold water, the entwisted membranes will expand and reassume their original beautiful hue,* and by a dexterous address may be

* If the transparent isinglass be held in certain positions to the light, it frequently exhibits beautiful prismatic colours.

perfectly unfolded. By this simple operation we find that isinglass is nothing more than certain membranous parts of fishes divested of their native mucosity, rolled and twisted into the forms above mentioned and dried in the open air.

The sounds or air bladders of fresh water fish in general are preferred for this purpose, as being the most transparent, flexible, delicate substances. These constitute the finest sorts of isinglass; those called *book* and *ordinary staple* are made of the intestines, and probably of the peritonæum of the fish. The belluga yields the greatest quantity, as being the largest and most plentiful fish in the Muscovy rivers; but the sounds of all fresh-water fish yield more or less fine isinglass, particularly the smaller sorts, found in prodigious quantities in the Caspian sea, and several hundred miles beyond Astracan, in the Wolga, Yaik, Don, and even as far as Siberia, where it is called *kla* by the natives, which signifies a glutinous matter; it is the basis of the Russian glue, which is preferred to all other kinds for its strength. The sounds, which yield the finer isinglass, consist of parallel fibres, and are easily rent longitudinally, but the ordinary sorts are found composed of double membranes, whose fibres cross each other obliquely, resembling the coats of a bladder; hence the former are more readily pervaded and divided with subacid liquors, but the latter, through a peculiar kind of interwoven texture, are with great difficulty torn asunder, and long resist the power of the same menstruum; yet when duly resolved are found to act with equal energy in clarifying liquors.

Isinglass receives its different shapes in the following manner:

The part of which it is composed, particularly the sounds, are taken from the fish while sweet and fresh, slit open, washed from their slimy *sordes,* divested of

every thin membrane which envelopes the sound, and then exposed to stiffen a little in the air: in this state they are formed into rolls, about the thickness of a finger, and in length according to the intended size of the staple, a thin membrane is generally selected for the centre of the roll, round which the rest are folded alternately, and about half an inch of each extremity of the roll is turned inwards. The due dimensions being thus obtained, the two ends of what is called *short staple*, are pinned together with a small wooden peg, the middle of the roll is then pressed a little downwards, which gives it the resemblance of a heart shape, and thus it is laid on boards or hung up in the air to dry. The sounds which compose the *long staple* are longer than the former; but the operator lengthens this sort at pleasure by interfolding the ends of one or more pieces of the sound with each other: the extremeties are fastened with a peg like the former, but the middle part of the roll is bent more considerably downwards, and in order to preserve the shape of the three obtuse angles thus formed, a piece of round stick, about a quarter of an inch diameter, is fastened in each angle with small wooden pegs, in the same manner as the ends. In this state it is permitted to dry long enough to retain its form, when the pegs and sticks are taken out, and the drying completed; lastly, the pieces of isinglass are collected in rows, by running pack-thread through the pegholes, for convenience of package.

The membranes of the book sort being thick and refractory, will not admit a similar formation with the preceding; the pieces therefore, after their sides are folded inwardly, are bent in the centre in such a manner that the opposite sides resemble the cover of a book, from whence its name; a peg being run across the middle, fastens the sides together, and thus it is dried like the former. This sort is interleaved and the pegs run across

the ends, the better to prevent its unfolding. That called *lake isinglass* is formed of the bits and fragments of the staple sorts, put into a flat metalline pan, with a very little water, and heated just enough to make the parts cohere like a pancake when it is dried, but frequently it is over-heated, and such pieces, as before observed, are useless in the business of fining. Isinglass, is best made in the summer, as frost gives it a disagreeable colour, deprives it of weight, and impairs its gelatinous principles; its fashionable forms are unnecessary, and frequently injurious to its native qualities. It is common to find oily putrid matter and *exuviæ* of insects between the implicated membranes, which through the inattention of the cellerman often contaminate wines and malt liquors in the act of clarification. These peculiar shapes might probably be introduced originally with a view to conceal and disguise the real substance of isinglass and preserve the monopoly, but as the mask is now taken off, it cannot be doubted to answer every purpose more effectually in its native state, without any subsequent manufacture whatever, especially to the principal consumers, who hence will be enabled to procure sufficient supplies from the British colonies. Until this laudable end can be fully accomplished, and as a species of isinglass more easily procurable from the marine fisheries may probably be more immediately encouraged, it may be manufactured as follows:

The sounds of cod and ling bear great analogy with those of the *accipenser* genus of Linnæus*—and are so generally well known as to require no particular description.

The Newfoundland and Iceland fishers split open the fish as soon as taken, and throw the back bones with the sounds annexed in a heap. But previous to incipient

* Acipenser Huso.

putrefaction, the sounds are cut out, washed from their slimes and salted for use. In cutting out the sounds the intercostal parts are left behind, which are much the best; the Iceland fishermen are so sensible of this, that they beat the bone upon a block with a thick stick, till the pockets, as they term them, come out easily, and thus preserve the sound entire. If the sounds have been cured with salt, that must be dissolved by steeping them in water before they are prepared for isinglass; the fresh sound must then be laid upon a block of wood whose surface is a little elliptical, to the end of which a small hair brush is nailed, and with a saw-knife the membranes on each side of the sound must be scraped off. The knife is rubbed upon the brush occasionally to clear its teeth; the pockets are cut open with scissars and perfectly cleansed of the mucous matter with a coarse cloth; the sounds are afterwards washed a few minutes in lime-water, in order to absorb their oily principle, and lastly in clear water. They are then laid upon nets to dry in the air, but if intended to resemble the foreign isinglass, the sounds of cod will only admit that called *book;* but those of ling of both shapes. The thicker the sounds are, the better the isinglass, colour excepted; but that is immaterial to the brewer, who is its chief consumer. This isinglass resolves into fining, like the other sorts, in subacid liquors, as stale beer, cyder, old hock, &c. and in equal quantities produces similar effects upon turbid liquors, except that it falls speedier and closer to the bottom of the vessel, as may be demonstrated in tall cylindrical glasses; but foreign isinglass retains the consistency of fining preferably in warm weather, owing to the greater tenacity of native mucilage. Vegetable acids are, in every respect, best adapted to fining; the mineral acids are too corrosive, and even insalubrious in common beverage.

It is remarkable, that during the conversion of isinglass into fining, the acidity of the menstruum seems greatly diminished, at least to taste; not on account of any alkaline property in the isinglass probably, but by its inveloping the acid particles. It is likewise reduceable into jelly with alkaline liquors, which indeed are solvents of all animal matters; even cold lime water dissolves it into a pulpous *magma*. Notwithstanding this is inadmissible as fining, on account of the menstruum, it produces admirable effects in other respects; for, on commixture with compositions of plaster, lime, &c. for ornamenting walls exposed to the vicissitudes of weather, it adds firmness and permanancy to the cement; and if common brick mortar be worked up with this jelly, it soon becomes almost as hard as the brick itself; but for this purpose it is more commodiously prepared, by dissolving it in cold water, acidulated with vitriolic acid; in which case, the acid quits the jelly, and forms with the lime a *selenetic* mass, while at the same time the jelly being deprived in some measure of its moisture, through the formation of an indissoluble concrete amongst its parts, soon dries, and hardens into a firm body, whence its superior strength and durability are easily comprehended.

It has been long a prevalent opinion, that Sturgeon, on account of its cartilaginous nature, would yield great quantities of isinglass; but on examination no part of this fish, except the inner coat of the sound, promised the least success. This being full of *rugae*, adheres so firmly to the external membrane, which is useless, that the labour of repeating them supercedes the advantage. The intestines, however, which in the larger fish extend several yards in length, being cleansed from their mucus and dried, were found surprisingly strong and elastic, resembling cords made with the intestines of other animals, com-

monly called *cat-gut*, and from some trials, promised superior advantages when applied to mechanical operations.

Isinglass is also of great use in medicine, and cookery.

EXPERIMENTS ON GLUE MAKING.

To the editor of the Tradesman, or Commercial Magazine.

SIR *Berwick*, 8*th June*, 1809.

ON looking over the 7th Number of your Magazine, I observe a letter from Perth, with some observations on making glue. I am not so perfectly acquainted with the process of glue making as to give complete directions to any person wishing to embark in that manufactory, but making experiments on a variety of substances, which seemed likely to be converted into that article, engrossed much of my attention for some years. Some of my experiments may possibly excite a smile from the professed chemist, but at the same time I am persuaded that they may be of some use to the practical experimentalist, and may possibly save a great deal of both time and trouble to any who may be inclined to pursue the same object. My time would not admit of putting down in writing the twentieth part of my experiments, but the result of the most conspicuous is perfectly fresh in my memory.

I learn one useful lesson from your correspondent, which is, we should never be too confident, that we have collected all and every information which a town, a certain district, or journey may procure, however minute our observation and enquiries may have been; I had no idea that there was a town or village, either in the north or south, but some person knew that all sorts of animals' skins, and every kind of leather, (except such as had re-

ceived less or more of the tanning,) was easily capable of being converted into glue, or boiled down into a jelly, which is adopted to various useful purposes without going through the full process of glue making. What first engrossed my attention, was the vast quantities of scraps and parings of tanned leather thrown away from curriers' work houses, and every shoemaker's shop. What struck me was, that if any means could be fallen on to extract the tan, that all these which are at present thrown to the dunghill, might be converted to a valuable purpose.

My first experiment was to steep a quantity of small pieces of tanned leather in water, renewing it regularly before it came to a state of putrefaction, as whenever that takes place, the substance of the leather is rendered entirely unfit for the intended purpose; but while any of the tan seemed to remain in the leather, the water kept fresh a very long time: how long I continued this, I cannot exactly say, but at least six or nine months. The water at last came off perfectly clear, and the leather seemed so soft and pliable, I had some hopes my object was obtained; but when boiled after the manner of dissolving other leather, I found that in place of dissolving into a soft or pulpy-like substance, it turned hard and brittle; if the boiling was long continued, it separated into a kind of corney substance, or into small particles, but never dissolved so as to intermix with the water. My next experiment was putting the leather into a weak solution of different acids: I thought it possible that some of these might either dissolve the tan, or at least be more powerful in extracting it than pure water; this was very often repeated, and at each renewal the leather was carefully washed with water, to prevent its being in any degree corroded by the acid. The same experiment was tried with a solution of alkali, but when the operation of boiling was again resorted to, the appearances were more unpromis-

ing than the former. My last experiment was steeping the leather with a certain quantity of fuller's-earth; this, of all the other substances which I tried, seemed to produce the best effect. In length of time the tan appeared to be entirely taken out, and the leather seemed as soft and had nearly the same feel as when taken from the animal; but when I reverted to the boiling, although the appearances were much more favourable, the desired effect was by no means produced: what effect longer perseverance might have had, I cannot determine, for I now began to tire. My curiosity was next directed towards fish; I tried various experiments on almost every kind caught on these shores, and the result of all was nearly the same. I soon found that the skins and fins of fish are not difficult to boil into a kind of glue, and the substance was of a most adhesive and tenacious quality, but appeared to be too susceptible of the least damp, and soon became soft. The bones, if boiled for a considerable length of time, became so soft as easily to rub into a very fine white powder, but the fish itself exhibited the most curious appearances. I have often examined it with a glass of great magnifying powers, and the appearance is beautiful; the whole appears one pure lucid pulpy substance. I was, at first, confident, that the whole would, with ease, dissolve into a soapy substance, if not into glue, but how different was the result? after boiling a very long time, the whole dissolves into a thready substance, and although continued for several days, there was not the smallest difference, only the quantity reduced from its original bulk, yet the water never appeared in the least thickened, and when suffered to stand at rest, the whole settled to the bottom without shewing the smallest tendency to incorporate with the water. If a solution of either pot or pearl-ashes is used, the fish will easily melt down into a soft soapy substance, and the solution is made pretty strong, the dissolved sub-

stance will wash much the same as soft soap. I was still anxious (if possible) to fall on some method to dissolve fish without the intervention of any other substance but water. I put a certain quantity into a jar, which was kept perfectly close, till the whole was completely dissolved into a fine soft soapy mass, but the smell was so intolerable, it was almost impossible to examine it with much attention. I thought this a good opportunity to try the effect of alkali in a state of solution, to destroy any infection, or to counteract putrefaction. I mixed the putrefied fish with a weak solution of pearl-ashes, when I was most agreeably surprized to find the offensive smell destroyed in a few minutes; the only flavour which the fish retained, was resembling horn, which had got a small scorch with fire, but it was no way offensive or disagreeable.

I tried numerous other experiments relative to making glue, particularly with the common rosin, by mixing it with some substance, so as to make it soluble in water. Rice affords a glue mucilage, which in a certain degree effected that purpose; from linseed I found the same, &c. But I am afraid I have already tired your readers, who may feel very little interest in these matters; but of this I am certain, the chemical experimentalist will eagerly catch at every hint which may throw some light on the effect produced by the combination of different substances, and I can assure all those who have leisure time, that no study, I had almost said no amusement, will afford so large a fund of entertainment as chemical experiments. I well know that repeated disappointments will attend the most skilful operator, and the most plausible compounds will often produce a substance very different from what is expected; but even these very disappointments produce such appearances as doubly to increase our curiosity, and only gives a greater excitement to make farther experi-

ments. It likewise has this singular advantage, that while it amuses the mind, gratifies curiosity, and enlarges all the intellectual faculties, it in general gives a good deal of exercise to the body.

I am, Sir, your's, &c.
JAMES GRAHAM.

METHOD OF MANUFACTURING GLUE.

To the editor of the Tradesman, or Commercial Magazine.

SIR,

I HAVE observed in your seventh number a correspondent asking for particulars on the manufacture of glue, and again in your eighth number, page 114. In your thirteenth number, for July last, are also the results of several experiments on the clippings and parings of tanned leather, and fish bones, by Mr. James Graham, of Berwick; but I think the following process of making glue, as furnished by Mr. J. Clennell, of Newcastle, about the year 1802, is the most concise and simple of any I have read, and corresponds exactly with the practical part of that manufacture, of which I have been an eye-witness for several years, in the neighbourhood of Acton, on the road to Uxbridge. I will therefore make use of Mr. C's. own words.

"The improvement (he observes) of any manufacture depends upon its easy access to men of science, and a prudential theorist can never be better employed than in attempting to reduce to regularity or to system the manufactures that may fall under his attention. In conformity to the first principle, I made some notes whilst visiting a glue manufactory, a few years ago, in Southwark, and those interwoven with the remarks on that subject, of some chymists of the first respectability, I take the liberty of sending you; at the same time I must beg of you, or your correspondents, that where they may be corrected

in any manner, it may be done, and I shall feel myself obliged by the attention.

"Glue is an inspissated jelly made of the parings of hides or horns of any kind, the pelts obtained from furriers, and the hoofs and ears of horses, oxen, calves, sheep, &c. quantities of all which are imported, in addition to the home supply, by many of the great manufacturers of this article; these are first digested in lime water, to cleanse them as far as it can from the grease or dirt they may have contracted; they are then steeped in clean water, taking care to stir them well from time to time; afterwards they are laid in a heap, and the superabundant water pressed out; then they are boiled in a large brass cauldron, with clean water, skimming off the dirt as it rises, and further cleansed by putting in, after the whole is dissolved, a little melted alum or lime finely powdered, which by their detersive properties still further purge it; the skimming is continued for some time, when the mass is strained through baskets and suffered to settle, that the remaining impurities, if any, may subside; it is then poured gently into the kettle again, and further evaporated by boiling a second time, and skimming until it becomes of a clear, but darkish brown colour: when it is thought to be strong enough (which is known either by the length of time a certain quantity of water and materials have boiled, or by its appearance during ebullition) it is poured into frames or moulds of about six feet long, one broad, and two deep, where it hardens gradually as the heat decreases: out of these troughs or receivers it is cut, when cold, by a spade, into square pieces or cakes, and each of these is placed within a sort of wooden box, open in three divisions to the back; in this the glue, as yet soft, is taken to a table by women, where they divide it into three pieces,* with an instrument not unlike a

* When the women by mistake cut only two, that which is double the size is called a bishop, and thrown into the kettle again to be manufactured afresh.

bow, having a brass wire for its string; with this they stand behind the box, and cut, by its opening, from front to back; the pieces thus cut are taken out into the open air, and dried on a kind of coarse net work, fastened in moveable sheds of about four feet square, which are placed in rows in the glue-maker's field, every one of which contains four or five, or more rows of net-work; when perfectly dry and hard it is fit for sale.

"That is thought the best glue which swells considerably without melting, by three or four days immersion in cold water, and recovers its former dimensions and properties by drying. Glue that has got frost, or that looks thick and black, may be melted over again and refined, with a sufficient quantity added of fresh, to overcome any injury it may have sustained; but it is generally put into the kettle, after what is in it has been purged in the second boiling. To know good from bad glue, it is necessary for the purchaser to hold it between his eye and the light, and if it appears of a strong dark brown colour, and free from cloudy or black spots, the article is good."—So far Mr. Clennell.

A glue that is colourless, and of superior quality, is obtained of the skins of eels, and known by the name of *size*. It is also procured from vellum, parchment, and different species of white leather; but for common purposes this is by far too expensive, and is only made use of in those cases of delicate workmanship where glue would be too gross. The skins of the rabbit, hare, and cat are also made use of in the manufacturing of size, by those who are employed in gilding, polishing, and painting in various colours.

Another fine species of glue is known by the name of *isinglass*, and is the produce of a certain fish very common in the Russian seas. From various foreign writers on the subject of glue, it appears that it was first principally pre-

pared from the membranous and cartilaginous parts of animals, and after being dried, they were melted into tablets. It is certain, however, that every animal substance containing jelly may be used in the manufacture of glue; and, according to Duhamel, a strong but black-coloured glue may be obtained from bones and hartshorn, after they are dissolved in Papin's digester. The English glue, is reckoned far superior to any kind manufactured abroad, and furnishes an article of exportation to the continent; and the Dutch society of arts and manufactures have long offered premiums for a specimen equal to the English, the Flanders glue being considerably inferior to that manufactured in England, and that manufactured in France is still worse.

From the experiments of Parmentier, it appears that six pounds of button-maker's raspings yielded a pound of excellent glue, not inferior to that which is manufactured in England. The glue which he obtained from the filings of ivory was equally good, but more highly coloured. The filings of horn yielded none of this substance. To obtain glue as colourless as possible, a very small quantity of water should be employed for extracting the jelly, by which means it may be concentrated without long evaporation, as exposure to heat has always a greater or less influence on the colour in proportion to the time. The whiteness and transparency of the Flanders' glue are said to originate from an adherence to this plan.

In their consistence, colour, taste, smell, and solubility, glues are found to differ from each other considerably. Some glues will dissolve by agitation in cold water, while others are only soluble at the point of ebullition. It is generally admitted that the best of glue is transparent, of a brownish yellow colour, and having neither taste nor smell. It is perfectly soluble in water, forming

a viscous fluid, which, when dry, preserves its tenacity and transparency in every part, and has more solidity, colour, and viscidity, in proportion to the age and strength of the animal from which it is produced.

Glue is of the greatest use in many of our principal manufactories, particularly that of hats.

EBOR.

Remarks by the Editor.—Near Philadelphia the process is this. The cuttings parings, &c. of skins, and other materials that will boil to a jelly, are immersed for 2 or 3 days in lime water, to take off the hair. They are then washed well. They are put in a coarse canvass bag, suspended by a chain from a large iron arm fixed in the brickwork. The bag is immersed in the boiler of water: the materials are gradually dissolved. The feculences, add to the dung heap. The solution is evaporated till on trial being cold, it is gelatinous; in this state, while hot, it is poured into long wooden moulds somewhat broader than the usual breadth of a piece of glue. It is then cut into lengths while in the box, by children, who take out the solid mass of jelly, being a little longer, a little broader than the usual size of glue-cake, and thick enough (the depth of the wooden trough, box, or mould) to make half a dozen cakes of glue. It is then carried and placed before the man who cuts it. This is done by a square frame with brass wires, set at such distance apart, that each cutting will make a cake of glue. By one motion, pressing the brass wires through the jelly toward his breast against which a board is placed, half a dozen, (or if necessary, more) cakes of glue, or rather of jelly, are cut and separted at once. These are carried away, put upon netting under a shed, and dried gradually in the air: by which means, the jelly is hardened into glue.

This business, cannot be carried on, but between Sep-

tember and May, on account of the materials being so liable to putrefaction. For the same reason they omit no Sundays, the necessity of the business requiring it. I think about 2lb. of rosin per hundred weight, would make the glue better, and enable the manufacturer to work a month longer.

On the Art of covering Wire Cloth with a transparent Varnish, as a Substitute for Horn; and on other Objects of public Utility. By ALEXIS ROCHON, *of the National Institute of France, &c.**

IN the progress of the present war, the marine storehouses of France were totally without the essential article of horns for lanthorns. It was impossible to substitute glass in the place of this article, on account of its brittleness, and the obvious danger which might result from that quality. In this situation of distress, the agents of the French government consulted Citizen Rochon, and directed him to make every experiment he could think of to discover a proper substitute. His attention was first directed to a memoir of the celebrated Poivre on the fabrication of lanthorns of horn by the Chinese. It is known that this industrious nation prefer horn to glass on account of its cheapness and toughness, and that they possess the art of welding this substance together with so

* Extracted from a memoir read to the National Institute of France the 21st Ventose, in the year VI. (March 11th, 1798), and inserted in the Journal de Physique for April 1798. The memoir contains various political and economical observations more particularly applicable to France, with general observations, which I have not thought it necessary either to transcribe or abridge; neither have I been solicitous to take the very words of my author in the parts I have abstracted. N.

much delicacy, that they make lanthorns of two feet diameter of astonishing transparency, and to all appearance of one single piece. It is also known that the Chinese use the horns of goats and sheep only, which they soften and split into laminæ by processes supposed to be unknown in Europe; or, perhaps, by employing a proportion of human labour and patience for that purpose which the European demand might be inadequate to repay. Citizen Rochon, who does not appear to be perfectly aware of the degree of accuracy with which the same art of splitting horn is practised in Europe, proposed, that the horns of beeves should be sawed into laminæ, and then scraped and polished; or, to which he gives the preference, that they should be laminated in boiling water.

While this active philosopher was employed at Brest in establishing a manufactory for laminating the horns of beeves, which he purposed to reduce into the state of a paste by means of pure alkali in the digester of Papin, it occurred to him, that he might supply the pressing wants of the navy by another expedient, which consisted in the application of a coating of glue upon wire cloth.

In this process, he at first tinned the iron wires of the sieve cloth he made use of, but afterwards found it more convenient, in every respect, to give it a slight coating of oil paint to preserve it from rust. The glue he made use of was afforded by boiling the clippings of parchment with the air-bladders and membranes of sea-fish; materials which he used, not from any notion that they were preferable to isinglass, but because they were the cheapest he could procure. He added the juice of garlick and cyder to his composition, in proportions which, I suppose, he did not measure, but which he found to communicate great tenacity and somewhat more of transparence than it would have possessed without them. Into this transparent and very pure glue or size, he plung-

ed his wire cloth, which came out with its interstices filled with the compound. It is requisite that the size should possess a determinate heat and consistence, concerning which, experience alone must guide the operator.

When this prepared wire cloth is fixed in the lanthorn, it must be defended from moisture by a coating of pure drying linseed oil; but even in this state it is not fit to be exposed to the weather. The ease with which these lanthorns are repaired in case of accident, by a slight coating of glue, is pointed out as a great advantage by the inventor, who likewise informs us that they were used in the expedition to Ireland as signal lanthorns, though contrary to his wishes. For this use he recommends the large plates of mica, which were then imported from Boston. With the latter substance, enclosed between two pieces of very open wire cloth, he made certain squares, 26 inches in length and 18 in width, for the light-house at Ushant, which had been damaged by a flock of wild ducks, that flew through the windows and dashed out the lights.

Citizen Rochon affirms, that lanthorns of wire cloth, prepared in his method, are much cheaper than those made of tin and horn; that they are very cheaply repaired, and afford a stronger light.

He applied coarse iron wire cloth to another use, which, he thinks, may be worth attention in future. He made the roof of one of his workshops of this wire-cloth in order to avoid the danger of fire, and covered it with a slight coating of plaister. He thinks that a composition of lime and pounded scales of iron would have been preferable. This coating ought not to be thicker than a slate; and he recommends that it should be penetrated with boiling whale oil, and painted with tar and ochre. Such a roof would afford no hold for the wind, and might, as he apprehends, be of considerable use to defend buildings and sheds which require particular defence against fire.

In the course of experiments made for the discovery of a varnish proper to defend his new lanthorns from moisture, Citizen Rochon did not employ resins or copal, which are always somewhat friable, but a perfect solution of elastic gum in drying linseed oil. This varnish or unguent having fixed the attention of Genouin, that learned chemist demanded whether it might not be practicable to use it in making bougies and other medical instruments, which were also at that time very much wanted. From this suggestion, Rochon employed the English machine for weaving whips to make the more consistent part of the instrument. He plunged this woven piece in a mixture of melted wax with a little ochre, then drew it through a wire plate to take off the superfluous wax, and render it perfectly smooth; after which he applied the varnish of elastic gum, which completed the instrument.

Sartori, ornamental painter at Brest, pointed out to our operator that fish glue is preferable to parchment size upon open wire cloth, because it is more transparent and stronger.

ROPE MAKING.

Mr. John Curr's (Sheffield), Patent, for laying a Rope, or twisting and forming the Strands together that compose the round Rope.—"Presuming (says Mr. Curr) that there is in use a wheel, or engine, for twisting the strands at the top end of the ropery, and another moveable one towards the bottom end of the ropery, and that the large tooth-wheel, in each of these wheels that drive round the small nut-wheels, contain ninety-four teeth each; and that there are three smaller nuts working into the tooth-wheel of the wheel, or engine, at the top end of the rope-

ry occasionally, that contain fourteen teeth each; and three more that contain twenty-five teeth each; and three more that contain fifty teeth each; which are also occasionally put into geer for twisting up the strands, or for laying a rope to accommodate different sizes and dimensions of ropes; and that there are three small nut-wheels working into a tooth-wheel, above described, of the wheel, or engine, at the bottom end of the ropery, occasionally, that contain eight teeth each, and three more that contain fourteen teeth each; and three more that contain twenty-eight teeth each; which are also put into geer for twisting up the strands, or for laying a rope to accommodate different sizes and dimensions of ropes. Now, in order to lay, or twist a shroud-laid rope regularly, from end to end, and to keep the fore-twist of the strands and the back-twist of the rope always regular, this invention requires that a wheel, or reel, or other apparatus, shall be attached to the wheel, or engine, at the lower end of the ropery above described, in such a manner as to point out and command the speed of the moveable top, or laying-block, commonly used in laying a rope. And the nut-wheels, at the top-end of the ropery employed in twisting the strand, should be so proportioned to the nut-wheels, employed at the same time in twisting the rope at the bottom end, as that it shall require an equal number of turns on the wheel at both ends of the ropery, to give the proper twist or hardness to the rope, so that the workmen making one revolution or turn of the one wheel, or engine, at the same time as the workmen do on the other end, a regular proportion of twist is effected and kept up.—To simplify these principles, a view of the wheel, or reel, is prefixed to the specification.

The strands being all then put upon the axis of the nut, with 14 teeth on the engine, at the bottom end of the ropery, and upon the separate nuts with 25 teeth on the

wheel, or engine, at the top end; the wheel, or reel, on which the cord or wire laps, being fixed to the diameter of eighteen inches and a half, for a rope of three inches circumference; and both wheels, or engines, being turned with the same velocity, or, in other words a revolution being made of the wheels at the bottom and top end of the ropery, at one and the same time (which, as they are in sight of each other, may easily be done), the cord, or wire, will then turn off the reel, and govern the speed of the top, which will produce a rope nearly regular, in twist and in hardness. To make a shroud-laid rope of greater or less circumference than the third-inch rope above described, the diameter of the wheel, or reel, will require to be lessened or enlarged two inches in diameter for every three-eighths of an inch the ropes are more or less in circumference, in which case, the twist of the rope will be found tolerably near the twist of a hard-laid rope, and close a cable-laid rope on these wheels, or make a shroud-laid rope of larger circumference than four inches and a half. The three strands may be put upon the nut-wheel, at the bottom end of the ropery, containing twenty-eight teeth; and the single strands upon the wheel, at the top end, with fifty teeth; in which case the wheel, or reel, will be fixed to half the diameter of the above directions. If the above-mentioned proportion of teeth does not harden the rope, to the discretion of the ropemaker, the nuts at the top-end, with a tooth less each, will make the ropes harder; and with a tooth more each will make them softer; and lessening, or enlarging the wheel, or reel, gives more or less twists in the rope. The ropes being thus made, by a regular system, will, if the spinning be well done, and if the rope-maker, in getting the strands to the full hardness, be careful to cease twisting when the moveable wheel, or engine, at the bottom end of the ropery, is at one and the same place with each

of the strands, to give the same hardness to all of them, and the ground on which the sledge, that holds back the moveable wheel or engine, at the bottom end of the ropery works, to keep the strands in proper tension, be regular and even, be very nearly regular in twist and hardness, from end to end; and for the cable-laid ropes, consisting generally of three small shroud-laid ropes, or for making flat-ropes, all of which require the ropes being made to great accuracy, that they may all take a regular stretch together, when applied to use, will be found a great acquisition and improvement in the strength and wear of them; and in any detached shroud-laid rope this regularity in the manufacturing will be found of great service.

TEA TRAYS.

A Composition for making Trays, Waiters, and various Articles by Presses or Stamps,

By Mr. Thomas Jones, of Bliston, Staffordshire. The ingredients used are varied according to the size of the articles to be manufactured. For those that are small, he takes 1000lbs. of rope, 20lbs. of rags, and for large articles 100lbs. of rope, and 100lbs. of rags are added. These are reduced to a pulp, and mixed with a certain small proportion of vitriolic acid. Various other materials are mentioned, but those above stated are deemed the best; and to make the said pulp into different articles, Mr. J. recommends that a wire or other sieve of a similar size and shape to the article required, to be taken and used in the manner directed in the specification. To render the mode of operation intelligible, the Patentee has given an example, shewing in what way the frame and sieve are placed

to collect the composition or pulp for making an oval canoe. He then puts on a flannel or woollen cloth, and upon that a board, and then turns the pulp out of the sieve upon the flannel and board upon the top of it, and presses the same together lightly, to force out part of the liquid by which the pulp felt is made. This being between the dies or tools of the shape of the articles wanted, is put into a press, in order to render it at once solid, and of the required shape. It is now to be put into a stove or oven of a proper degree of heat, where it is kept till it is nearly, but not entirely dry, and then it is to be taken out of the oven, put between the dies and pressed violently, so as to set it and make it smooth. After this it is put into the oven again till it is perfectly dried; but great caution must be used to prevent it from warping; this is effected by means of a frame, made in the form of the inside of the articles, and weights to keep it in its proper form. It may next, if necessary, be hammered over to make it smooth and flat, and then being perfectly dry, it is to be dipped in the Japan liquid, and there suffered to remain till the said liquid has perfectly penetrated it, when it is to be dried and varnished. The dies may be made of iron, or any other metal, or hard substance.

REMARKS BY THE EDITOR.

The preceding series of papers on isinglass, glue, rope making, and tea trays, suggest methods of saving scraps and fragments that would otherwise be thrown away as useless. The parings of leather might be further applied, as in England, to the making of snuff boxes, pocket inkstands, segar boxes, &c. The articles are reduced to shavings, macerated in warm water, and pressed in moulds of the required shape and size. They are then dried and varnished, the black with black japan, the brown with amber varnish.

In the hot summer of the year 1780 (the summer of the memorable Lord George Gordon Riots) I attended during the long vacation of the colleges at Oxford, a course of anatomical lectures under Mr. Sheldon (who afterward published on the anatomy of the lymphatic system.) Afrer that course, I, with several other anatomical students, attended veterinary dissections at a repository for dead horses in St. John's, Clerkenwell. I there was taught how usefully the meanest and most trifling articles might be employed under the direction of scientific skill: and I have from that time ceased to wonder at the pre-eminence in manufactures which the English have obtained, who so well know the value of saving and of using, what the negligent ignorance of foreign artists would abandon as worthless. We have a tolerably good poem on the life and death of a blood horse, "The high mettled racer," tracing his progress from being the favourite of the turf, through all the grades of hardships, till he is worn out with hunger, labour and blows, in the cart of the scavenger; I fear, a faithful account, not much to the credit of British Humanity*. I will now trace the progress of a *dead horse* through all the stages of his posthumous utility, greatly to the credit of the skill and frugality of that most ingenious people, as economical manufacturers.

A gentleman's horse dies. The routine of disposing of the dead animal, is this.

He is sent to the sadler, who gives credit for him at a Guinea. The sadler gives notice to the currier, who has the horse conveyed to some repository for dead horses; where he is skinned, and the currier takes away the skin, leaving the carcase. The skin, is depiled by lime, drest and tanned in the usual way: the offal of the skin cut off

* I republished about three years ago, Lord Erskine's admirable speech on cruelty to animals: it well deserves frequent perusal.

by the currier is sold to the glue maker: the offal of the leather during the process or after tanning, is laid by and sold to the makers of snuff-boxes, &c.

The dead horse, is a subject for dissection to young students in comparative anatomy, who pay for the licence of going to the repository, a guinea a quarter. The flesh is then cut off, boiled, and sold to people who hawk it about the streets of London in wheelbarrows, as cat's meat and dog's meat, at 1 1-2*d.* per lb.

The hoofs, are sold to the makers of Prussian blue. The bones, are sold to two descriptions of manufacturers: 1st, to the makers of cart-grease, who reside at the outskirts of London, and boil the bones for the sake of the fat and marrow; which, when cold, is skimmed off, and mixed with an equal quantity of tar to make the composition necessary to grease carriage wheels. Or, 2dly, they are sold to the manufacturers of volatile alkali, who make spirit of hartshorn, and sal ammoniac out of them, by distilling in large iron cylinders. The bones thus boiled down, used in my time, to be sent back again to a steam mill near St. John's, Clerkenwell, where they were ground into a coarse powder, and sold as a top dressing for grain crops. T. C.

ON PATENTS.—BY THE EDITOR.

THIS subject is now becoming very important, and is intimately connected with the whole range of domestic manufacture. The number and nature of the patents granted under the laws of the United States, have hitherto contributed little to the improvement of manufactures, but threaten much to the increase of lawsuits and impositions. I propose to offer a few remarks on this topic: and as we are not likely to throw aside the lights we may acquire from British precedents, and British practices, I shall give a summary of the decisions of that country on this set of questions.

By the 6th section of 21 James 1. ch. 3. the enacting clauses of that statute against monopolies generally, are declared not to extend to letters patent, and grants of privileges for 14 years or under, thereafter to be made, for the sole working or making of any manner of *new* manufactures within this realm, to the true and first inventor of such manufactures, which others at the time of making such letters patent shall not use, so as also, they be not contrary to law—nor mischievous to the state by raising the prices of commodities at home—or hurt of trade—or generally inconvenient.

The following comprize all the cases of consequence on patent rights, not including the questions on the copy-right of authors. The cases in Godbolt are too obsolete to be noticed.

3 Inst. 184. 1 Hawk. 233, Birscot's case. In which, additions to known manufactures are said not to be entitled to patent. But this case was overruled by Lord Mansfield in Morris v. Branson.

5 Co. 94. a, Barwick's case: a false suggestion will avoid a grant.

Edgberry v. Stephens, Salk. 447. 1 Hawk. 233. Inventions imported from abroad, never before used at home, entitled to patent. I shall observe upon this doctrine presently. This is the foundation for the New York patent to Livingston and Fulton.

Rex v. Mussary, 12 Geo. 2. Buller, N. P. [75.]

Morris v. Branson, 1776, Buller, N. P. [77.] Stocking frame.

Liardet v. Johnson, 1778, Buller, N. P. [76.] Patent stucco: usually, but falsely cited as a case on a patent for elastic trusses.

Rex v. Arkwright, 1785, Buller, N. P. [77.] Cotton spinning.

Rex v. Else, 1785, Buller, N. P. 76.

Turner v. Winter, 1787, 1 Durnf. & East, 602. Patent mineral yellow.

Boulton and Watt v. Bull, 1795, 2 H. Blacks. 463. 3 Vez. 140. Court divided on the law. Steam engine.

Hornblower v. Boulton and Watt, in error, 1799, 8 Durnf. and East, 95. Steam Engine.

Harmer v. Plane, 1807, 14 Vez. 130. Woollen cloth.

Much of the discussion in the cases of Boulton and Watt consists of argument on the grammatical meaning of the words manufacture, machine, method, principle.

The points substantially determined by these cases, may be reduced to the following heads.

1st. No patent is valid, in England, for any thing contrary to law—for any thing mischievous to the state by raising the price

of commodities at home—for any thing hurtful to trade—or generally inconvenient.

2dly. No patent is valid for any manufacture or invention in use at home before.

3dly. No manufacture or invention in use before, can be prohibited, or stopped on account of any patent granted for a new invention.

4thly. The specification must be filed in chancery within the time prescribed.

5thly. The specification must be full and precise; sufficiently ample and intelligible in itself; and must contain a plain description of every article, mode, process, and method, necessary to enable an artist of reasonable skill in the subject matter, to succeed in imitating the invention specified; without further explanation, or the necessity of trying any preliminary experiment. This complete disclosure, being the consideration for which the temporary monopoly is granted. Turner's patent for making mineral yellow, was set aside for ambiguity. Sir Richard Arkwright's patent for his cotton-spinning machine, was set aside (as I recollect) on account of his omitting to specify a weight and the place of it, necessary to make the machine go. A patent for elastic trusses was set aside, because the temper of the steel was improved by greasing it, which the patentee, who used tallow for the purpose, concealed. Any mode of misleading the public by ambiguity, concealment, or falsehood in the specification—by the introduction of unnecessary articles or processes, or the suppression of such as are necessary, will be fatal to the patent right. The patentee must enable the public to use his invention upon as simple and easy terms as he uses it himself.

6thly. The specification must pointedly describe the precise invention or improvement on which the patent is grounded; so that the public may know specifically, what the artist claims as peculiar to himself: and in such manner, that any person contesting the patent, may be enabled to meet the precise claim of novelty. It must not intermingle what was known before, with what is claimed as new, so as to render the latter ambiguous. The invention must be distinguished from what was previously known.

7thly. If the patent be grounded on an addition to, or an improvement of what was in use before, the patentee must confine his claim distinctly to the addition or improvement; and not take out a patent including the inventions of others who have preceded

him, as well as his own; if he does, the patent is void. If the addition be to a machine or manufacture already patented, the last patentee cannot use the first without license, or the first patentee use the addition without license.

8thly. It does not seem fully settled, whether a patent can be supported for an *abstract principle* however new. Judicial opinions are divided on this head. Thus, the Marquis of Worcester in his Century of Inventions, mentions one, of an engine which can be set to work and kept at work by the mere force of steam arising from boiling water. Would the Marquis have been entitled to a patent, for the exclusive use of all engines and machines whereof the moving power was the force of steam?

The better opinion seems, not. The ways and means, the method or variety of methods, and the machinery, by which steam can be applied as a moving power, seems legally requisite to be set out, previous to the establishing of such a patent. Otherwise the public may rest in doubt whether this *can* be done; moreover the patentee who conceals his method of doing it, is hardly entitled to a patent.

But where the method of effecting this, is plain and obvious to an artist of common skill, so as not to need a particular description, the want of it will not vitiate the patent. Thus, the patent of Boulton and Watt, was finally established for condensing the steam in a reservoir or box at a distance and separate from the working cylinder; although the precise method employed by them was not described. I am however not prepared to acquiesce in this much litigated decision, without great hesitation. *Perhaps* if the method actually employed were described, it would so far satisfy the law, as to cover any other after-found method of putting in practice the same principle. But I offer this in great doubt.

Upon this head, it is worthy to be considered, that if a patent can legally be supported for a principle merely, no improvement however important in the method of putting it in practice, can be used during the existence of the patent-right. The monopoly is not merely a pecuniary tax on the community, but an obstacle also to future invention. Thus, if a patent had existed for the principle of raising water, or moving machinery by means of steam, and Savary's method had been used—none of Watt's improvements could have been brought into use during the patent-term. Hence the propriety of confining the patent to the *method* of doing the thing. Hence also patents are properly granted for

new, more simple, and effectual methods of using a well known principle, as in steam engine patents.

But it should seem doubtful whether a *new application* of an old method or principle, ought to be a ground for a patent right, *unless it obviously requires considerable skill in varying the application.*

Thus, if a patent be granted for a new apparatus to distill aqua fortis, it would be absurd to grant another for its application to spirit of salt. If steam be applied to turn a cotton mill, it would be idle to grant another patent to one who applied it to a grist mill. The owners of the Albion mills never attempted to take out a patent. Perhaps its application to moving vessels on water, or carriages on land, would require machinery so different, as to furnish some foundation for a patent right; but in such case the specification and the claim, might include a description of the machinery used.

There is a colliery about four miles from the town of Leeds, in Yorkshire, from whence there is an iron rail road to Leeds. A friend of mine, lately from England, informed me, that he had seen a steam engine in a waggon on that rail road, drawing after it *twenty-two waggons*, each laden with three tons of coals; in all 66 tons. The wheels and the rail way, were reciprocally cogged. They moved at the rate of four miles an hour. Granting this to be, as I believe it is not, the foundation of a patent right, would any body support another patent for driving *coaches* by steam? Hence it should appear very difficult to lay down any certain rule on the subject. In England, the jury aided by the court, might determine whether a patent contested on the ground of frivolity ought to be supported, under the head of its being of general inconvenience. That is, as it now appears to me, for I find no judicial determination hereon. In this country, the question is becoming daily more interesting, where patents, frivolous, absurd, and fraudulent, threaten to become taxes on the community, in favour of persons, who may truly be said to raise money under false pretences.

9thly. A patent may be granted for an invention or improvement introduced from abroad: for the benefit is the same to the public, whether the knowledge be obtained by travelling, or by studying.

This is founded on the case in Salkeld, a very loose reporter. It may be right in the infancy of the communication of knowledge;

but I apprehend it is a doctrine, which must be received with some modifications in the present day.

For instance: could a patent have been supported in England, for the precise mode of bleaching by means of the oxymuriatic acid which every chemist in England was well acquainted with by the instructions of Berthollet?

Could any person in this country take out a patent for those inventions of Watt, that are included in his specification, when that specification is given at length in the reported cases of Boulton and Watt against Bull, and Hornblower against Boulton and Watt, and in the Repertory of arts?

The Repertory of Arts, the Philosophical Journals of Nicholson and Tilloch, the Magazines and Encyclopædias, of England, are books containing many english and continental inventions: they are books far from being uncommon in this country: they are open to all readers who will procure them: is it reasonable that a patent should be supported for any of the inventions described to the world and published for common benefit in either of these, or similar publications, in our own language?

If a patent be taken out, for an invention described in books known generally to scientific readers, I apprehend there is no sufficient reason to support it: the discovery is made and presented to the public, and belongs to the public: but if a process or method, or machine, or manufacture, not described in any book, be used in England or on the continent of Europe, and imported hither, there seems to be good reason for granting a patent right for its introduction.

So, though it were published in the French, German, Swedish, or Russian languages only: for at the present day, these languages, and the books published therein (French perhaps excepted*) are not commonly known even to scientific men in England or this country. If it be said, this would establish a fluctuating rule, I acknowledge it; but I contend that the rule ought reasonably to fluctuate with the advancements of science, and the facilities of scientific communication.

10thly. I do not find it any where determined, that the manufacture, engine, machine, method, process or principle for which a patent is takent out, should be in actual use and opera-

* I doubt whether the Annals de Chimie, the Journal de Rozier, the Journal des Mines, the Memoires D'Arcueil, the Reports of the National Institute, are sufficiently common, for my remarks to apply to them.

tion at the time of taking out the patent or filing the specification. I strongly incline to think, this ought to be the case, either at the filing of the specification or within some reasonable time after, according to the nature of the invention: but I do not find it laid down as necessary. How can it be ascertained that an invention is useful, and deserving of a patent right, till it be shewn to be so, by actual experiment? or why should a patentee enjoy his right to a monopoly, who leaves other persons at their own risk to ascertain the practicability and utility of the proposed invention?

11thly. Moreover, I think it may be inferred from the observations of some of the bench arguendo, that the person who merely suggests a theory or *principle*, is not entitled to a patent, but he only is so entitled, who first reduces it to practice and ascertains at his own expence of time, money and labour, the utility of the proposal. And this appears to me so reasonable, that I think it may well be adopted under some limitations. Sufficient time should be allowed to the first person who suggests an useful principle to reduce it to practice: a time, that must be limited according to the nature of the invention. A man can easily put together his improvements on the escapement of a watch, for instance; but a steam engine is not perfected in a week, or a month, or a twelve-month. If a man will permit his suggestions to lay idle and fruitless for years, he ought to be considered as having abandoned any exclusive right to them. Indeed all the common doctrine of abandonment, will apply to patents.

It is upon this principle, that the patent to *Livingston and Fulton* for their steam boats can be best defended. *Fitch* lost his right by abandonment through non-user. *Rumsey* did not succeed so as to bring his steam boat into full use. *Lord Stanhope* also failed in England. After these failures, the persons who succeeded, appear to have a reasonable claim to a patent monopoly, sufficiently extensive to cover the whole application of steam to the impelling of vessels on water; for less would hardly justify so expensive an experiment.

12thly. A patent may be set aside by scire facias, or stopt in limine by caveat; but as in England every person takes out a patent at his own risk, and on his own responsibility, the usual course is, that persons willing to contest the patent right, use the invention and leave the patentee to his remedy at law. This remedy is an action on the case against the person infringing the patent right. The declaration should set forth the invention in general terms, the patent, the specification duly enrolled, with averments

that it is a new manufacture (a word to which great latitude of construction is given) not used before within the realm of England, that the patentee is the first inventor or introducer, that the invention is not contrary to law, or mischievous to the state, or hurtful to trade, or generally inconvenient (following the statute) and that the defendant at a certain time and place fraudulently used or imitated the same in whole or in part, as the case may be, to the damage of the plaintiff.

13thly. Injunction will be granted against persons infringing a patent right, until the right be tried in a court of law; even in the face of strong objections to the specification. Haymer v. Plane, 14 Vez. 130. Boulton and Watt v. Bull, 3 Vez. 140. Indeed, the rule is, that persons in possession are entitled to injunction, which the court may grant either on terms or without.

Such are the leading cases and points on the subject of Patent rights in England: including, as it seems to me, some useful and important principles.

The laws of *this country* upon the subject are as follow. I copy Graydon's Digest, title PATENTS.

ACT of February 21, 1793. (Vol. II. p. 200.)

1. SECT. I. When any person or persons being a citizen or citizens of the United States, shall allege that he or they have invented any new and useful art, machine, manufacture or composition of matter, or any new and useful improvement on any art, machine, manufacture or composition of matter, not known or used before the application, and shall present a petition to the se-

cretary of state, signifying a desire of obtaining an exclusive property in the same, and praying that a patent may be granted therefor, it shall and may be lawful for the said secretary of state, to cause letters patent to be made out in the name of the United States, bearing test by the president of the United States, reciting the allegations and suggestions of the said petition, and giving a short description of the said invention or discovery, and thereupon granting to such petitioner, or petitioners, his, her or their heirs, administrators or assigns, for a term not exceeding fourteen years, the full and exclusive right and liberty of making, constructing, using and vending to others to be used, the said invention or discovery, which letters patent shall be delivered to the attorney general of the United States, to be examined; who, within fifteen days after such delivery, if he finds the same conformable to this act, shall certify accordingly at the foot thereof, and return the same to the secretary of state, who shall present the letters patent thus certified, to be signed, and shall cause the seal of the United States to be thereto affixed: And the same shall be good and available to the grantee or grantees, by force of this act, and shall be recorded in a book, to be kept for that purpose, in the office of the secretary of state, and delivered to the patentee or his order. [See *postea* 10.]

2. Sect. II. *Provided always*, That any person, who shall have discovered an improvement in the principle of any machine, or in the process of any composition of matter, which shall have been patented, and shall have obtained a patent for such improvement, he shall not be at liberty to make, use or vend the original discovery, nor shall the first inventor be at liberty to use the improvement: And it is hereby enacted and declared, that simply changing the form or the proportions of any machine, or composition of matter, in any degree, shall not be deemed a discovery.

3. Sect. III. Every inventor, before he can receive a patent, shall swear or affirm, that he does verily believe, that he is the true inventor or discoverer of the art, machine, or improvement, for which he solicits a patent; which oath or affirmation may be made before any person authorized to administer oaths, and shall deliver a written description of his invention, and of the manner of using, or process of compounding the same, in such full, clear and exact terms, as to distinguish the same from all other things before known, and to enable any person skilled in the art or science, of which it is a branch, or with which it is most nearly connected, to make, compound, and use the same. And in the case

of any machine, he shall fully explain the principle, and the several modes, in which he has contemplated the application of that principle or character, by which it may be distinguished from other inventions; and he shall accompany the whole with drawings and written references, where the nature of the case admits of drawings, or with specimens of the ingredients, and of the composition of matter, sufficient in quantity for the purpose of experiment, where the invention is of a composition of matter: which description, signed by himself, and attested by two witnesses, shall be filed in the office of the secretary of state, and certified copies thereof shall be competent evidence, in all courts, where any matter or thing, touching such patent right, shall come in question. And such inventor shall, moreover, deliver a model of his machine, provided the secretary shall deem such model to be necessary.

4. Sect. IV. It shall be lawful for any inventor, his executor or administrator, to assign the title and interest in the said invention, at any time, and the assignee having recorded the said assignment, in the office of the secretary of state, shall thereafter stand in the place of the original inventor, both as to right and responsibility, and so the assignees of assigns, to any degree.

Sect. V. *is repealed and supplied.* [See *postea* 12.]

5. Sect. VI. *Provided always*, That the defendant in such action shall be permitted to plead the general issue, and give this act and any special matter, of which notice in writing may have been given to the plaintiff or his attorney, thirty days before trial, in evidence, tending to prove, that the specification, filed by the plaintiff, does not contain the whole truth relative to his discovery, or that it contains more than is necessary to produce the described effect, which concealment or addition shall fully appear to have been made, for the purpose of deceiving the public, or that the thing, thus secured by patent, was not originally discovered by the patentee, but had been in use, or had been described in some public work, anterior to the supposed discovery of the patentee, or that he had surreptitiously obtained a patent for the discovery of another person: In either of which cases, judgment shall be rendered for the defendant, with costs, and the patent shall be declared void.

6. Sect. VII. Where any state before its adoption of the present form of government, shall have granted an exclusive right to any invention, the party claiming that right, shall not be capable of obtaining an exclusive right under this act, but on relinquishing his right, under such particular state, and of such relinquish-

ment, his obtaining an exclusive right under this act shall be sufficient evidence.

SECT. VIII. *is obsolete.*

7. SECT. IX. In case of interfering applications, the same shall be submitted to the arbitration of three persons, one of whom shall be chosen by each of the applicants, and the third person shall be appointed by the secretary of state: And the decision or award of such arbitrators, delivered to the secretary of state, in writing and subscribed by them, or any two of them, shall be final, as far as respects the granting of the patent; And if either of the applicants shall refuse or fail to choose an arbitrator, the patent shall issue to the opposite party. And where there shall be more than two interfering applications, and the parties applying shall not all unite in appointing three arbitrators, it shall be in the power of the secretary of state to appoint three arbitrators for the purpose.

8. SECT. X. Upon oath or affirmation being made, before the judge of the district court, where the patentee, his executors, administrators or assigns reside, that any patent, which shall be issued in pursuance of this act, was obtained surreptitiously, or upon false suggestion, and motion made to the said court, within three years after issuing the said patent, but not afterwards, it shall and may be lawful for the judge of the said district court, if the matter alleged shall appear to him to be sufficient, to grant a rule, that the patentee, or his executor, administrator or assign, shew cause, why procees should not issue against him to repeal such patent. And if sufficient cause shall not be shewn to the contrary, the rule shall be made absolute, and thereupon the said judge shall order process to be issued against such patentee, or his executors, administrators or assigns, with costs of suit. And in case, no sufficient cause shall be shewn to the contrary, or if it shall appear, that the patentee was not the true inventor or discoverer, judgment shall be rendered by such court for the repeal of such patent; and if the party, at whose complaint the process issued, shall have judgment given against him, he shall pay all such costs, as the defendant shall be put to, in defending the suit, to be taxed by the court, and recovered in due course of law.

9. SECT. XI. Every inventor, before he presents his petition to the secretary of state, signifying his desire of obtaining a patent, shall pay into the treasury thirty dollars, for which he shall take duplicate receipts; one of which receipts he shall deliver to the secretary of state, when he presents his petition: And the money,

thus paid, shall be in full for the sundry services, to be performed in the office of the secretary of state, consequent on such petition, and shall pass to the account of clerk-hire in that office. *Provided nevertheless*, That for every copy, which may be required at the said office, of any paper respecting any patent, that has been granted, the person obtaining such copy, shall pay at the rate of twenty cents, for every copy-sheet of one hundred words, and for every copy of a drawing, the party obtaining the same, shall pay two dollars: Of which payments, an account shall be rendered, annually, to the treasury of the United States, and they shall also pass to the account of clerk-hire, in the office of the secretary of state.

SECT. XII. *repeals the act passed April* 10, 1790, (Vol. I. p. 99,) *with the proviso*, That nothing, contained in this act, shall be construed to invalidate any patent, that may have been granted under the authority of the said act; and all patentees under the said act, their executors, administrators and assigns, shall be considered within the purview of this act, in respect to the violation of their rights: Provided, such violation shall be committed, after the passing of this act.

ACT of April 17, 1800. (Vol. V. p. 88.)

10. SECT, I. All and singular the rights and privileges given, intended or provided to citizens of the United States, respecting patents, for new inventions, discoveries, and improvements, by the act entitled "An act to promote the progress of useful arts, and to repeal the act heretofore made for that purpose," shall be, and hereby are extended and given to all aliens who at the time of petitioning in the manner prescribed by the said act, shall have resided for two years within the United States, which privileges shall be obtained, used, and enjoyed, by such persons, in as full and ample manner, and under the same conditions, limitations and restrictions, as by the said act is provided and directed in the case of citizens of the United States. *Provided always*, That every person petitioning for a patent for any invention, art or discovery, pursuant to this act, shall make oath or affirmation before some person duly authorized to administer oaths, before such patent shall be granted, that such invention, art or discovery hath not, to the best of his or her knowledge or belief, been known or used either in this or any foreign country; and that every patent which shall be obtained pursuant to this act, for any invention, art or discovery, which it shall afterwards appear had been known or used pre-

vious to such application for a patent, shall be utterly void. [See *antea* 1.]

11. Sect. II. Where any person hath made, or shall have made, any new invention, discovery or improvement, on account of which a patent might, by virtue of this or the abovementioned act, be granted to such person, and shall die before any patent shall be granted therefor, the right of applying for and obtaining such patent, shall devolve on the legal representatives of such person in trust for the heirs at law of the deceased, in case he shall have died intestate; but if otherwise, then in trust for his devisees, in as full and ample manner, and under the same conditions, limitations and restrictions, as the same was held or might have been claimed or enjoyed by such person, in his or her lifetime; and when application for a patent shall be made by such legal representatives, the oath or affirmation, provided in the third section of the beforementioned act, shall be so varied as to be applicable to them. [See *antea* 3.]

12. Sect. III. Where any patent shall be, or shall have been granted pursuant to this or the abovementioned act, and any person without the consent of the patentee, his or her executors, administrators or assigns first obtained in writing, shall make, devise, use, or sell the thing whereof the exclusive right is secured to the said patentee by such patent, such person so offending shall forfeit and pay to the said patentee, his executors, administrators or assigns, a sum equal to three times the actual damage sustained by such patentee, his executors, administrators or assigns, from or by reason of such offence, which sum shall and may be recovered, by action on the case founded on this and the abovementioned act, in the circuit court of the United States, having jurisdiction thereof.

Sect. IV. *is a repealing clause.*

So far the acts of our country.

In the case of Parsons v. Barnard and Parsons v. Wigton, 7 Johnson's Rep. 144, it was determined that the state courts have no jurisdiction in suits on patents: a determination clearly right in point of law, but pregnant with many inconveniences, and a source of numerous and vexatious impositions: for manufacturers at a distance from the metropolis of a state, are strongly deterred by calculations of prudence, from contesting a right at quadruple the expence they can compromise the demand. I am fully aware on the other hand, of the hardship of dragging a patentee and his

witnesses into every petty court of the United States; still the case requires a remedy, or patents will become a public evil of no slight magnitude.

Some north-eastern speculator, I heard of lately, procured or pretended to have procured, a patent right for using stone coal in a blacksmith's forge: on being taxed with the strangeness and uselessness of such a patent, he replied "no matter: it will be worth "while for every blacksmith to give me a couple of dollars for a "right rather than contest it with me." It has proved a good speculation. I wish it were the only successful case of contributions levied on the public, by the bold speculations of patentees.

I do not know of any other than two cases decided on patents in our American courts.

The first case is the contested right of Messrs. Livington and Fulton, against Van Ingen and others to an exclusive privilege in New York state for the use of their steam boat, decided in 1812.

By several acts of the assembly of New York state, an exclusive right was granted to Livingston and Fulton, to navigate the waters of that state by means of vessels propelled by steam. It appears that the appellants, Livingston and Fulton, did not arrogate to themselves the invention of the steam engine employed, or the means and method of applying it, so as to propel the vessels; they claimed merely to be the *possessors* of a method of applying the steam engine to propel a boat on new and advantageous principles. Fitch's grant to navigate by steam, stood in the way; but as Fitch had never made any attempt during ten years to put in execution his method of navigating by steam, it was (in my opinion rightly) considered as renounced and abandoned. This case is reported in 9 Johnson's Rep. 507, and Halls law Journal, V. 4. p. 169.

Livingston and Fulton applied to the court of chancery for an injunction, against Van Ingen, which was denied by Chancellor Lansing, whose opinion was revised on error and overruled. I think rightly.

The objections were principally, 1st. That the monopoly granted by the state legislature of New York, was an infringement on the exclusive right of congress to grant patents. 2ly. That they infringed on the exclusive right of congress to regulate commerce. 3ly. That the injunction ought not to be granted, inasmuch as the legislative acts had provided a remedy which the patentees were limited to pursue.

The reply to the first ground was, that the powers of congress were to be construed strictly: they had power to grant patents to

inventors only. This was not pretended to be an invention; the appellants were possessors only of a new and advantageous me-method; but it was the introduction of an improvement of so much importance, as fully to justify the bargain made by the legislature on behalf of the public with the appellants, Livingston and Fulton. It had been fully settled in England, that the *introducers* of inventions and improvements, were entitled to patent rights. 2ly. The power of granting patents was not of an exclusive, but a concurrent nature.

As to the second ground, it was said, that this was no more regulating commerce, than laws concerning ferries or stage coaches could be said to be so. This had nothing to do with exports or imports.

As to the third ground, it was shewn to be the usual course, for the court of chancery to grant injunctions in favour of persons in the actual possession of rights; sometimes without, sometimes upon terms of speedy trial of the right at law. The appellants Fulton and Livingston succeeded.

In this case, the state allowed some years to enable the applicants to bring to perfection, and into actual use, their contemplated improvement: an allowance, which the magnitude of the undertaking well deserved.

The other case was decided in Feb. 1813, by judges Duvall and Houston, of Maryland, in favour of Oliver Evans against some millers near Baltimore. I have not seen a report of the case, but I understand that the point decided was this. Oliver Evans's patent for his elevators was declared illegal. He applied for an extension of his term of monopoly, and obtained it. In the interval, after the annulling of his first patent, and previous to obtaining his second, while the invention (if it was one) was open to all the world, some millers had put up machines of the nature of his elevators. On obtaining his second patent, he brought suit against them; and the court charged the jury, that the defendants were liable to pay for these machines, erected when no law forbad their erection, and no patent stood in the way of their use. A decision so dubious, that I much wonder at the acquiescence of the defendants under it. I have understood that a similar decision was made by judge Washington and judge Peters in Philadelphia. I greatly respect all these gentlemen: still, the decision appears to me a very strange one.

Such is the *law* on the subject so far as I can briefly trace it.

The following letter of Mr. Jefferson, contains so much matter worthy of consideration as to patent rights, that I think it worth while to subjoin it, without interfering any way, or giving any opinion as to the collateral question of Mr. Oliver Evans's patents. It appears to have been written in consequence of a request made to Mr. Jefferson, to give his sentiments on the validity of Mr. Evans's claim. I copy it from Niles's Register, addenda to the 5th volume.

Monticello, August 13th, 1813.

SIR,

Your letter of August 3d, asking information on the subject of Mr. Oliver Evans's exclusive right to the use of what he calls his Elevators, Conveyers and Hopperboys, has been duly received. My wish to see new inventions encouraged, and old ones brought again into useful notice, has made me regret the circumstances which have followed the expiration of his first patent. I did not expect the retrospection which has been given to the reviving law; for although the second proviso seemed not so clear as it ought to have been, yet it appeared susceptible of a just construction; and the retrospective one being contrary to natural right, it was understood to be a rule of law, that where the words of a statute admit of two constructions, the one just and the other unjust, the former is to be given them. The first proviso takes care of those who had lawfully used Evans' improvements under the first patent; the second was meant for those who had lawfully erected and used them after that patent expired, declaring they "should not be liable to damages therefor." These words may indeed be restrained to uses already past; but as there is parity of reason for those to come, there should be parity of law. Every man should be protected in his lawful acts, and be certain that no ex post facto law shall punish or endamage him for them. But he is endamaged if forbidden to use a machine lawfully erected at considerable expense, unless he will pay a new and unexpected price for it. The proviso says, that he who erected and used lawfully shall not be liable to pay damages: but if the proviso had been omitted would not the law, construed by natural equity, have said the same thing? In truth both provisos are useless. And shall useless provisos, inserted pro majori cautela, only authorise inferences against justice? The sentiment that ex post facto laws are against natural rights is so strong in the United States, that few, if any, of the state constitutions have failed to proscribe them. The federal con-

stitution indeed interdicts them in criminal cases only; but they are equally unjust in civil as in criminal cases: and the omission of a caution which would have been right, does not justify the doing what is wrong; nor ought it to be presumed, that the legislature meant to use a phrase in an unjustifiable sense, if by any rules of construction it can be even strained to what is just. The law books abound with similar instances of the care the judges take of the public integrity. Laws moreover abridging the natural rights of the citizen, should be restrained by rigorous constructions within their narrowest limits.

Your letter, however, points to a much broader question, whether what have received from Mr. Evans the new and the proper name of Elevators are of his invention: because, if they are not, his patent gives him no right to obstruct others in the use of what they possessed before. I assume it as a lemma, that it is the invention of the machine itself which is to give a patent right, and not the application of it to any particular purpose of which it is susceptible. If one person invents a knife convenient for pointing our pens, another cannot have a patent right for the same knife to point our pencils. A compass was invented for navigating the sea; another could not have a patent right for using it to survey land. A machine for threshing *wheat* has been invented in Scotland; a second person cannot get a patent right for the same machine to thresh *oats*; a third *rye*; a fourth *peas*; a fifth *clover*, &c. A string of buckets is invented and used for raising water, ore, &c. can a second have a patent right to the same machine for raising wheat, a third oats, a fourth rye, a fifth peas, &c.? The question then whether such a string of buckets was invented first by Oliver Evans, is a mere question of fact in mathematical history. Now turning to such books only as I happen to possess, I find abundant proof that this simple machinery has been in use from time immemorial. Doctor Shaw, who visited Egypt and the Barbary coast, in the years 1727—8, 9, in the margin of his map of Egypt, gives us the figure of what he calls a Persian wheel, which is a string of round cups, or buckets, hanging on a pully, over which they revolve, bringing up water from a well, and delivering it into a trough above. He found this used at Cairo, in a well 264 feet deep, which the inhabitants believe to have been a work of the patriarch Joseph. Shaw's Travels, 341, Oxford edition of 1738, in folio, and the Universal History, I. 416, speaking of the manner of watering the high lands in Egypt, says—" Formerly they made use of Archi-

medes' Screw, thence named the Egyptian Pump; but they now generally use Wheels (Wallowers) which carry a rope or chain of earthen pots, holding about 7 or 8 quarts a piece, and draw the water from the canals. There are besides, a vast number of wells in Egypt, from which the water is drawn in the same manner to water the gardens and fruit trees; so that it is no exaggeration to say, that there are in Egypt above 200,000 oxen daily employed in this labour." Shaw's name of Persian wheel has been since given more particularly to a wheel with buckets, either fixed or suspended on pins at its periphery.—Mortimer's Husbandry, 1, 18, Duhamel, V. Ferguson's Mechanics, plate 13. But his figure, and the verbal description of the Universal History, prove, that the string of buckets is meant under that name. His figure differs from Evans' construction in the circumstances of the buckets being round, and strung through their bottom on a chain; but it is the principle; to wit, a string of buckets, which constitutes the invention, not the form of the buckets, round, square, or hexagon; nor the manner of attaching them, nor the material of the connecting band, whether chain, rope or leather. Vitruvius, L. X. c. 9, describes this machinery as a windlass, on which is a chain descending to the water, with vessels of copper attached to it; the windlass being turned, the chain moving on it will raise the vessels, which in passing over the windlass, will empty the water they have brought up into a reservoir: and Perrault, in his edition of Vitruvius, Paris, 1784, folio, plates, 61, 62, gives us three forms of these water elevators, in one of which the buckets are square, as Mr. Evans' are. Bossut, Histoire des Mathematiques, I. 86, says, "The drum wheel, the wheel with buckets, and the *chapelets*, are hydraulic machines, which come to us from the ancients; but we are ignorant of the time when they began to be put into use." The *chapelets* are the revolving band of buckets, which Shaw calls the Persian wheel, the moderns a chain pump, and Mr. Evans elevators. The next of my books, in which I find these elevators, is Wolf's Cours de Mathematiques, I. 370, and plate 1, Paris, 1747—8vo. Here are two forms; in one of them the buckets are square, attached to two chains, passing over a cylinder or wallower at top, and under another at bottom, by which they are made to revolve. It is a nearly exact representation of Evans' elevators. But a more exact one is to be seen in Desagulier's Experimental Philosophy, II. plate 34. In the Encyclopedie de Diderot et D'Alembert, 8vo. edition de Lausanne, 1st vol. of plates, in the four subscribed "Hy-

draulique, noria," is one, where round earthen pots are tied by their collars, between two endless ropes, suspended on a revolving lanthern or wallower; this is said to have been used for raising ore out of a mine. In a book which I do not possess, "L'Architecture Hydraulique de Belidor, the II vol. of which is said [De La Lande's continuation of Montucla's Histoire des Mathematiques, III. 711] to contain a detail of all the pumps, ancient and modern, hydraulic machines, fountains, wells, &c. I have no doubt this Persian wheel, chain pump, chapelets, elevators, by whichever name you choose to call it, will be found in various forms. The last book I have to quote for it is Proney's Architecture Hydraulique, I. advertisement VII. and sec's 648, 649, in the latter of which passages he observes, that the first idea which occurs for raising water is to lift it in a bucket by hand; when the water lies too deep to be reached by hand, the bucket is suspended by a chain and let down over a pully or windlass; if it be desired to raise a continued stream of water, the simplest means which offers itself to the mind is to attach to an endless chain or cork a number of pots or buckets, so disposed that the chain being suspended on a lanthern or wallower above, and plunged in water below, the buckets may descend and ascend alternately, filling themselves at bottom, and emptying at a certain height above, so as to give a constant stream. Some years before the date of Mr. Evans' patent, a Mr. Martin of Caroline county, in this state, constructed a drill plough, in which he used the band of buckets for elevating the grain from the box, into the funnel which let them down into the furrows: he had bands with different setts of buckets, adapted to the size of peas, of turnip seed, &c. I have used this machine for sowing benni seed also, and propose to have a band of buckets for drilling Indian corn, and another for wheat. Is it possible that in doing this I shall infringe Mr. Evans' patent? That I can be debarred of any use to which I might have applied my drill when I bought it, by a patent issued after I bought it.

These verbal descriptions applying so exactly to Mr. Evans' Elevators, and the drawings exhibited to the eye, flash conviction both on reason and the senses that there is nothing new in these elevators but their being strung together by a strap of leather. If this strap of leather be an invention entitling the inventor to a patent right, it can only extend to the strap, and the use of the string of buckets must remain free to be connected by chains, ropes, a

strap of hempen girthing, or any other substance except leather; but indeed Mr. Martin had before used the strap of leather.

The screw of Archimedes is as ancient at least as the age of that mathematician, who died more than 2000 years ago. Diodorus Siculus speaks of it, lib. 1, page 21, and lib. 5, page 217, of Stevens' edition of 1559, folio, and Vitruvius, X. 11. The cutting of its spiral worm into sections, for conveying flour or grain, seems to have been an invention of Mr. Evans', and to be a fair subject of a patent right, but it cannot take away from others the use of Archimedes' screw, with its perpetual spiral, for any purposes of which it is susceptible.

The Hopperboy is an useful machine and as far as I know original.

It has been pretended by some (and in England especially) that inventors have a natural and exclusive right to their inventions; and not merely for their own lives, but inheritable to their heirs: but while it is a moot question, whether the origin of any kind of property is derived from nature at all, it would be singular to admit a natural and even an hereditary right to inventions. It is agreed by those who have seriously considered the subject, that no individual has, of natural right, a separate property in an acre of land: for instance, by an universal law, indeed, whatever, whether fixed or moveable, belongs to all men equally and in common, is the property for the moment of him who occupies it; but when he relinquishes the occupation the property goes with it. Stable ownership is the gift of social law, and is given late in the progress of society: it would be curious then if an idea, the fugitive fermentation of an individual brain, could of natural right be claimed in exclusive and stable property. If nature has made any one thing less susceptible than all others of exclusive property, it is the action of the thinking power called an idea; which an individual may exclusively possess as long as he keeps it to himself, but the moment it is divulged, it forces itself into the possession of every one, and the receiver cannot dispossess himself of it. Its peculiar character too is that no one possesses the less because every other possesses the whole of it. He who receives an idea from me receives instruction himself without lessening mine; as he who lights his taper at mine receives light without darkening me. That ideas should freely spread from one to another over the globe for the moral and mutual instruction of man and improvement of his conditions, seems to have been peculiarly and benevolently

designed by nature when she made them, like fire, expansible over all space, without lessening their density in any point; and like the air in which we breathe, move, and have our physical being, incapable of confinement or exclusive appropriation. Inventions then cannot in nature be a subject of property. Society may give an exclusive right to the profits arising from them as an encouragement to men to pursue ideas which may produce utility. But this may or may not be done according to the will and convenience of the society, without claim or complaint from any body. Accordingly it is a fact, as far as I am informed, that England was, until we copied her, the only country on earth which ever by a general law gave a legal right to the exclusive use of an idea. In some other countries it is sometimes done in a great case and by a special and personal act; but generally speaking other nations have thought that these monopolies produce more embarrassment than advantage to society; and it may be observed that the nations which refuse monopolies of inventions are as fruitful as England in new and useful devices.*

Considering the exclusive right to invention as given, not of natural right, but for the benefit of society, I know well the difficulty of drawing a line between the things which are worth to the public the embarrassment of an exclusive patent and those which are not. As a member of the patent board for several years, while the law authorised a board to grant or refuse patents, I saw with what slow progress a system of general rules could be matured. Some however were established by that board. One of these was, that a machine of which we were possessed, might be applied by every man to any use of which it is susceptible, and that this right ought not to be taken from him and given to a monopolist, because he first, perhaps, had occasion so to apply it. Thus a screw for crushing plaister might be employed for crushing corn cobs; and a chain pump for raising water might be used for raising wheat—this being merely a change of application. Another rule was, that a change of material, should not give title to a patent; as the making a plough share of cast rather than wrought iron; a comb of iron instead of horn or of ivory; or the connecting of buckets by a band of leather rather than of hemp or iron. A third was, that a mere change of form, should give no

* I doubt this. The brevet d'invention, was a patent right in France, if I do not mistake; though I do not find it in the Code of the year 1804. T. C.

right to a patent; as a high quartered shoe instead of a low one, a round hat instead of a three square, or a square bucket instead of a round one; but for this rule, all the changes of fashion in dress, would have been under the tax of patentees. These were among the rules which the uniform decisions of the board had already established: and under each of them Mr. Evans' patent would have been refused. 1st, Because it was a mere change of application of the chain pump from raising water, to raise wheat. 2d, Because the using a leathern instead of a hempen band, was a mere change of material: and 3rdly, square buckets instead of round, are only a change of form; and the ancient forms too, appear to have been indifferently square or round. But there were still abundance of cases which could not be brought under rule, until they should have presented themselves under all their aspects; and these investigations occupying more time of the members of the board, than they could spare from higher duties, the whole was turned over to the judiciary, to be matured in a system under which every one might know when his actions were safe and lawful. Instead of refusing a patent in the first instance, as the board was authorised to do, the patent now issues of course subject to be declared void on such principles as should be established by the courts of law. This business however is but little analogous to their course of reading, since we might in vain turn over all the lubberly volumes of the law, to find a single ray which would lighten the path of the mechanic or mathematician; it is more within the information of a board of academical professors, and a previous refusal of a patent would better guard our citizens against harrassment by law suits. But England had given it to her judges, and the usual predominancy of her examples, carried it to ours.

It happened that I had myself a mill built in the interval between Mr. Evans's first and second patents. I was living in Washington, and left the construction of the mill entirely to the millwright. I did not even know he had erected elevators, conveyors and hopperboys, until I learnt it by an application, from Mr. Evans's agent for the patent price. Although I had no idea he had a right to it by law (for no judicial decision had then been given) yet I did not hesitate to remit to Mr. Evans the old and moderate patent price, which was what he then asked, from a wish to encourage even the useful revival of ancient inventions. But I then expressed my opinion of the law, in a letter either to Mr. Evans or to his agent.

I have thus, sir, at your request given you the facts and ideas which occur to me on the subject. I have done it without reserve, although I have not the pleasure of knowing you personally. In thus frankly committing myself to you, I trust you will feel it as a point of honour and candour to make no use of my letter, which might bring disquietude on myself;* and particularly I should be unwilling to be brought into any difference with Mr. Evans, whom, however, I believe too reasonable to take offence at an honest difference of opinion. I esteem him much, and sincerely wish him wealth and honour. I deem him a valuable citizen of uncommon ingenuity and usefulness; and had I not esteemed still more the establishment of sound principles, I should now have been silent. If any of the matter I have offered can promote that object, I have no objection to its being so used. If it offers nothing new, it will of course not be used at all.

I have gone with some minuteness into the mathematical history of the elevator, because it belongs to a branch of science, in which, as I have before observed, it is not incumbent on lawyers to be learned; and it is possible, therefore, that some of the proofs I have quoted, may have escaped on their former arguments.

On the law of the subject I should not have touched, because more familiar to those who have already discussed it, but I wished to state my own view of it merely in justification of myself; my name and approbation being subscribed to the act. With these explanations accept the assurances of my respect.

TH: JEFFERSON.

I have looked into the Code Napoleon of the year 14, for the law of France relating to Brevets d'invention, and into the published speeches of orators on that code, but I cannot find any thing on the subject.

Having now given all the information I am in possession of, as to the existing circumstances of patent rights, I shall offer my own suggestions on this difficult and interesting subject.

And First, I would premise, that although I do not consider persons whose time is so exclusively dedicated to legal discussions as the gentlemen of the profession in England, and indeed in this country, as fully competent to decide all the questions that can

* It is proper to observe, that though the author did not at the time writing this letter, contemplate its publication, yet his permission has since been obtained.

arise upon patents; yet I would by no means exclude the lights to be derived from a court of law. I think the preceding summary of decisions will shew, that much good sense, in the decision, has been the result of much and patient reflection in considering the subject of patent rights in England. Nor can we well dispense with the accuracy and precision of a court of law.

But in the case of Liardet and Johnson which I remember; in the case of Turner against Winter, reported; in the case of Oliver Evans at Baltimore; in the case of Livingston and Fulton against Van Ingen, before chancellor Lansing, notwithstanding the known abilities of the judges, a scientific man cannot but feel the want of scientific knowledge in the bench and the bar; and the narrow views taken of the subjects discussed. Yet more able men in their own profession, are not easily found.

I can well remember being sent up by a committee of manufacturers from Manchester, to oppose a patent for bleaching with oxymuriatic acid founded upon Berthollet's process. The question was heard before Macdonald, master of the rolls at his chambers: Graham was employed by the applicant for the patent, who hearing the torrent of voluble but unintelligible declamation uttered by his counsel, quitted the room in disgust, and left the master of the rolls to decide according to the best of his comprehension: who certainly did not understand one syllable of what was spoken, any more than the speaker.

Hence, secondly, I would propose a board of scientific men, to whom should be submitted, in the first instance, all applications for patents. Should they reject the application, let the applicant nevertheless take out his patent at his own risk; but accompanied with the reasons of the board for rejecting it; which reasons should be evidence for the consideration of a court and jury, in case the claim should be contested; and double costs awarded in all cases of final judgment against the patentee of an application thus rejected.

Thirdly, some provision should be made, to promulgate the patents taken out, at present, the specifications are as utterly unknown to the public at large, as if they had been filed only among the records of China. The office is useless: who but Dr. Thornton knows what it contains? And it is greatly to be doubted whether that gentleman, intelligent as he is, be much the wiser for the records of his office, for I do not know that it is his business to be so. At any rate, the public are not. Suppose, a volum-

every year, or oftener if need be, were published under the direction of the board, of the specifications and plates filed in the office—the sale would bear the expence: if not, raise the fees on issuing patents to cover the cost of publication. If this were done, the public might stand the chance of knowing a little of what is going forward in the patent office, and be somewhat the wiser for the discoveries of individuals: at present they know nothing; and patents are taken out by persons who may innocently infringe upon the discoveries of others.

Fourthly. The exclusive jurisdiction of the courts of the United States, gives rise to vexatious levies on the community. It is worth no man's while in the back country of any state, to resist a claim of 2 or 300 dollars, however unfounded, if he is to be dragged to the metropolis, court after court, to encounter an adversary, whose interest it is to render such a suit, by delays and removals, too expensive to be continued; and to bear down opposition, by the trouble and the cost attending upon it.

The remedy is difficult to be suggested; but I should suppose, that it would sufficiently guard the patentee against vexatious contests, if after one decision in any court of a state in his favour on the point in contest, he should be entitled, on producing the record, to double costs in every other suit on the same point, tried in the same state, wherein final judgment should be passed in his favour. In all suits brought by the patentee, every person interested ought to be allowed to become joint defendant, on motion after notice.

Such are my present opinions, which I throw out for public consideration. T. C.

COOKERY.

Cum labor extuderit fastidia, siccus, inanis,
Sperne cibum vilem: nisi Hymettia mella Falerno
Ne biberis diluta. Foris est Promus; et atrum
Defendens pisces hiemat mare: cum sale panis
Latrantem stomachum bene leniet. Unde putas aut
Qui partum? Non in caro nidore voluptas
Summa, sed in te ipso est. Tu pulmentaria quære
Sudando. Pinguem vitiis, albumque, nec ostrea
Nec scarus, aut poterit peregrina juvare Lagois.

Hor. Stat. 2.

THE art of cookery, is or ought to be employed for the purpose of rendering human food, 1st, more digestible. 2dly, more palatable. 3dly, to extract the greatest quantity of nutriment from a given quantity of food. 4thly, to ascertain what articles of food best combine the qualities of cheapness, pleasantness, wholesomeness, nutrition, and easy cookery. Under this view of the subject I shall offer to your consideration, my good friend, in the first place, what occurs to me on the Economy of cookery, and the principles that belong to the *Culina Pauperum*, and perhaps we may strike out something that even the rich may not despise. Something like this has been done by the Pharmacopæia Pauperum* of the British medical school, which under the notion of killing or curing the poor at a trifling expence, has introduced many valuable remedies. The use of the cold bath so much more extensively than heretofore, the use of Fowler's ague drop, and the substitution of oak bark and gentian for the Jesuit's bark, are among the truly valuable improvements.

You will say the poor do not read the Emporium: neither do they read Horace or Count Rumford: though I do almost think they would be almost as well employed in studying Rumford's essays on cookery, or Barlow's poem on hasty pudding, as Barlow's advice to the privileged orders, or his Conspiracy of Kings. But improvements in the condition of the poor, must be derived from knowledge communicated by those who are not poor. The poor have no time to think for themselves: unluckily the course of human affairs requires (less indeed in this country than else-

* I do not know of any regular Pharmacopæia under that name; but there is such a system in practice.

where) that their time shall be occupied in the labour of the body so much, as almost to exclude the labour of the mind.

But it may serve an useful purpose to consider the subject on *principle*.

The distinctive characters of a poor man's kitchen and a rich man's kitchen are these:

The aim of the poor man is to satisfy the cravings of *hunger* at the cheapest rate, at the least expence of food.

The aim of the rich man is to indulge the cravings of the *palate*, so that he may consume as much food pleasurably, as a due regard to health will permit.

Hence the poor man should consult in the food he purchases, 1st, cheapness. 2dly, nutriment. 3dly, that kind of food that will most speedily satisfy hunger, and at the same time afford sufficient nutriment.

For like reason, the rich man, would be led to purchase and prepare those articles, of which the greatest quantity can be consumed, consistently with health, previous to the appetite being satisfied: price, being a secondary consideration.

Hence, the provision of the poor should be *insipid*, so that no more food be consumed than the cravings of hunger absolutely require; sapidity incites to the devouring of needless quantity: while the provisions of the rich man, should be *sapid*; and his kitchen and his table abound in condiments.

Count Rumford, therefore, was considerate and humane, but on principle he was wrong, when he recommended hard-baked bread, cut in dices, to be mixed with the soup of the poor—and that it should be flavoured with herring to gratify the palate and prolong the repast. Upon strict principles of economy, there should be no temptation to indulgence beyond what nature absolutely requires. At times when indulgence may be invited, the question is changed: at such times the principles bear upon the cookery of the affluent.

Let us then consider what is the kind of food, that, at the cheapest price, afford most nutriment: and first of vegetables.

Wheat: rye: barley: oats: Indian corn: buckwheat: potatoes: rice.

I will suppose wheat, for instance at Carlisle, at 150 cents. Rye, 100. Barley, 125. Oats, 50. Indian corn, 75. Buckwheat, 75. Potatoes, 50. The wheat will weigh 60lbs. The rye and

barley 56. The oats 36. The Indian corn 56. Potatoes (heaped) 70. Buckwheat about 45.

The nutritious part of grain consists chiefly in the *fecula*, or starch, and the *gluten* it contains: not so much in the mucilage: not at all in the moisture.

Of the above substances, potatoes would be the cheapest, if it were not that the greatest part of their weight is moisture. In Ireland they are cheapest: for in Ireland, Lancashire, and Cheshire, potatoes may be bought at 15 to 20 cents per bushel, heaped. Rice, in a rice country, is the cheapest article of diet, but not here in Pennsylvania. The quantity of actual *nutriment* in the above substances consisting in the greatest proportion of fecula or starch, next of gluten, next of mucilage, would be in this order, viz.

Indian corn: wheat: barley: rye: potatoes: buckwheat: oats.

Their comparative *cheapness* will be, Indian corn: rye: barley: wheat: potatoes: buckwheat. Barley bread is very nearly as good as wheat bread: and abounds in fecula. Hence in Europe its use for beer, in preference to other grain.

It seems clear, that in point of economy, flour should be no further bolted, than to get rid of the husk or bran: if you go farther there is waste. The converting of flour into bread, greatly increases both its digestible and its nutritive qualities, for it is thereby partially decomposed, the farina, the gluten, and the mucilage are more intimately, and, I believe, chemically blended; and the digestive organs have less to do. The bulk also is increased, for 1lb. of fine flour will make more than 1¼lb. of bread. New bread is unwholesome, and is moreover an article of great extravagance; from the temptation to eat more than the calls of mere hunger require. For the purposes of family economy, it should be at least one day old. This fact was well established on the examination of the London bakers before a committee of the house of commons during the scarcity of 1808, 1809.

The toll paid for grinding grain, the trouble of transporting it to and from mill, and the fire employed in baking it, are equivalent, with a poor man, to one fourth of the value. In this respect, potatoes have a decided advantage in countries where fuel is scarce.

Buckwheat and oats appear to have too much husk or bran to put in their claim as cheap articles of diet in this country. Rice in the middle states is too dear. The superiority of Indian

corn, will, I think, be greater in Virginia and thence southward, where this kind of grain is grown to more perfection than wheat; which last is grown to more perfection in the middle states, than corn. Mackenzie in his travels across the American continent, somewhere, I think, says that Indian corn even at 10d. a lb. was the cheapest food they could lay in.

Of the other kinds of vegetables, cabbage, turnips, carrots, parsnips, beets, Jerusalem artichokes, peas, beans, &c. the cheapness depends on the price: and that, from the great imperfection of garden agriculture in this country, is so various in various districts and at various times, that nothing can be said satisfactorily on the subject. The sweeter the vegetable of this description, (as beet, parsnip, carrot) the more nutritive: but turnips *can* be raised and sold so as to afford the greatest quantity of this kind of food for the least price. The Jerusalem artichoke (*Helianthus tuberosus*) which stands the winters of this country admirably, and is very productive, appears to deserve more attention than has yet been bestowed upon it, as food for cattle: and in flavour and consistence, it bears a very close resemblance to the common garden artichoke, *Cynara scolymus*.

Potatoes, turnips, cabbages, and even carrots and beets, can be raised in England where land is dear, so as to be afforded as articles of food for cattle: owing to more labour, more capital, more skill bestowed upon land there. I know of very few places in this country where this can be done, and none where it is done. So true is it that cheapness of food does not depend upon cheapness of land, but on the facility of procuring labour. Provisions are at this moment one fourth cheaper in Paris than at New York, or even at Philadelphia.

Of Animal food. Generally speaking, the price of animal food, is every where double that of bread. In point of nutriment (except in the form of fat) it is twice as dear. Animal food may be considered as consisting of muscular flesh, fat and bone.

Muscular flesh consists of muscular fibre, (fibrin) sparingly soluble in water: of blood vessels, and lymphatic vessels with their contents: and nervous or medullary fibre. The blood contains gelatin, albumen, and the watery part of the serum; I know that Dr. Bostock denies the existence of gelatin, but my observations are not in accord with this. The gelatin is soluble, the albumen is coagulable. That much gelatin is contained in mus-

cular fibre is evident from the strong broth that can be made of it. Beef-tea for instance: while the albumen rises in scum. This broth also contains much of the contents of the lymphatic and the serum, which give flavour: the colouring particles of the blood, remain in the meat.

The fat is insoluble in water, but by means of flour as a *liaison*, may be rendered miscible with water. The use of liaisons, is of equal importance to the poor and the rich, and not well understood by either in this country.

Bones contain much gelatin and marrow, amounting to half their weight, which can be gotten out, by boiling in a pot with a close cover. In common practice you may dissolve one fourth of the weight of the bone.

In boiling, the coagulated albumen separates from the fibrin, and swims in the form of a scum, which is usually thrown away, but it is very nutritive; and by means of flour, as a liaison, can be made miscible with the broth. We regard the scum of a pot as dirt and feculent matter: it is not so, unless where dust has been negligently admitted. The poor therefore should not throw it away.

Of all the parts of an animal, the flesh is the least and the fat the most nutritive.

I think it worth while to detail my reasons at large; or rather my authorities.

1st. In all cold countries, where the climate requires strong food, animal oil is universally resorted to. I instance Kamschatka, Norway, Lapland.

2dly, In all warm countries, where meat is forbidden, either by poverty, by the climate, or by the priesthood, fat is necessary to support muscular strength. Thus in the East Indies among the Hindoos, oil and ghee, are universally used with the rice. In Italy and Spain, among the poor, oil of olive is necessary with their bread, salt, and garlic, where labour is to be performed.

3dly, Among the American Indians, bear's fat and bear's oil are universally held in first rate estimation from one end of the continent to the other. No jerk would support a travelling Indian, unless he had bear's oil to dip it in, or Tossamanonny to eat with it. (Young Indian corn, dried gradually to a chocolate brown, and reduced to a coarse powder.)

4thly, "I experienced," says M. De Pages, (in his travels on the Red river and thence to Natchitoches) "the truth of what is

" said of hunters who live entirely on animal food, but which I " used to find difficult to be believed, namely, that besides their " desiring little nourishment from the leaner part, it soon becomes " offensive to the taste, whereas the fat is both more nutritious, and " continues to be agreeable to the palate.

The late judge Henry in his account of the campaign against Quebec in 1775, p. 46 says, " we feasted till noon, and in the inter- " mediate moments culled the entrails *for the fat.* We broke the " bones and extracted the marrow, under the full persuasion that " *food of an oily nature*, is one of the strongest main stays of hu- " man life. Of this principle if we had a doubt we were shortly " afterwards most irrefragably convinced." Again: " By this " time the fat and marrow of the animals we had killed were ex- " hausted, and our stock of salt expended. One who has never " been deprived of bread and salt, nor known the absence of *oleagi- " nous* substances in his food, cannot make a true estimate of the " invaluable benefits of such ingredients in the sustentation of the " bodily frame."

5ly. Every person who has been conversant with Indians, or with the labouring class of people among the whites, or with surveyors who are much in the woods, knows the uniform and universal preference given by them to fat substances as food.

6ly. I know the fact, but I know not now the name of the noble Lord who dining with Mr. Bakewell of Ditchley, the great improver of the breeds of animals, (sheep, oxen and horses) said " Mr. " Bakewell, you improve your sheep to such a degree that they " are too fat to be eatable." " They may be too fat for your Lord- " ship, and the rich class of society; but you form a small part " only of our customers. We breed for the middling classes, and " the poor—for those who eat that they may be enabled to work, " and they know the value of fat, if your Lordship does not."

7ly. Capt. Lewis on his return from his expedition over this continent to the Pacific ocean twice related to me, that when their salt provisions were exhausted, although they sometimes killed deer, yet no quantity that the stomach could bear of the flesh of venison, would enable his people to go through a day's journey without great and exhausting fatigue, sometimes they would eat lean food when they could get it in plenty, from 6 to 7lb. of venison per man; but it did not suffice to sustain the strength of the company. A beaver's tail of a pound or a pound and a half weight, afforded much more nutriment as a meal for two people. All

persons who have eaten this article of food in the woods, speak of it as a great luxury. "An agreable barter ensued (says judge Henry) we gave salted pork in exchange for two fresh Beaver-tails, "which when boiled, renewed ideas of the May butter of our own "country." p. 23.

Of all meats the bear's meat is the most nutritive: and when not exceeding a year old the most delicious. I mean of meats usuallye aten here. The tail of the beaver, is not usually found in our markets, but bearmeat is; and opossum also is occasionally met with; a very nutritive animal. A bear ham, cured as common gammons are, with salt and salt petre, smoked and dried at my request in Mr. P's family, when dressed, measured six inches of fat, and about 1½ inch of lean. The fat while hot, was so transparent that you might almost read through a slice of it half an inch thick. But the bear was old, and the meat too strong.

Next to bear is pork: the meat universally prefered by hard working people. It was also the food of the Athletæ of old.

Next to pork I should rank beef: and next to beef, mutton. It has been ascertained by direct experiment, that game birds are sooner digested than common meats; and are probably not so nutritive, if we may judge by the analogy of venison. The circumstance related to me by Capt. Lewis, which I have had repeatedly confirmed on other occasions, as to the want of nutriment in venison, explains the reason why venison, and game generally are so fashionable at the tables of the rich: viz. because much of this kind of food can be eaten, without overloading the digestive powers.

These considerations lead us to conclude, that the greatest quantity of nutriment under the least weight, can be put up in the form of bacon fat, moderately salted, to be eaten with tossamanonny, or Indian corn just ripe parched to a light chocolate brown colour, and ground. To make variety, portable soup might be added; which if well seasoned, I think preferable to the salted lean or muscular part of pork. Bread cut in slices and gently baked to a chocolate brown, and then ground, might be substituted; but it is by no means equal weight for weight with parched Indian corn; of which about a handful mixed with water, is a day's meal for an Indian. A small bag of tossamanonny and a bottle of bear's oil, will suffice an Indian for a week's journey.

Were I to recommend the greatest quantity of wholesome nutriment, sufficiently varied not to pall upon the palate, and con-

tained in the smallest compass, I should say that 8 ounces of the fat of well-fed, moderately-salted, well dried pork, two ounces of seasoned portable soup, and 8 ounces of tossamanonny, would be nutriment sufficient to support a day's labour. This would amount to half the usual weight. The stomach requires distention from quantity, as well as mere nutriment; and this is given by the bulk which the parched corn acquires, when mixed with water.*

As to the economical principles of dressing food, they relate 1st. to the economising of the food. 2ly. To the economizing of the fuel.

In 36 Ph. Mag. 142, an account is given of some experiments on a large scale on dressing meat, that seem entitled to full credit.

280lb. of beef lost by boiling in	*lb. oz.*	
the common way - -	73. 14	or $26\frac{1}{2}$ per cent.
190lb. of beef lost by roasting	61. 2	or 32 per cent.
90lb. of beef lost by baking -	27. —	or 30 per cent.
Mutton lost by boiling - - -		$21\frac{1}{3}$ per cent.
Do. by roasting - - -		from $31\frac{2}{3}$ to $35\frac{1}{2}$ per cent.

These experiments decide the point, that the cookery of economy, is confined to stewing meat in close vessels; where the liquor in which the meat is boiled, shall be saved, and by the addition of cabbage, carrot, turnip, onion, leek, or all of these, with flour, form a part of the meal. Weight for weight, leek is superior in nutriment and in flavour to onion.

I have mentioned the soup of bones. These should be broken into pieces, and boiled, or rather simmered, in a close vessel. Much nutriment is thrown away in throwing away bones. This has been ascertained on a large scale at Manchester by the gentlemen who superintended the benevolent soup establishments there;

* The common rations of beef delivered to the soldiery, are defective in point of frugality, inasmuch as the bone is always thrown away by the men as useless: whereas bone will yield from 35 to 40 per cent. of very good soup. The camp kettles are ill contrived; they should have covers; which save both time and fuel. Every mess beside a camp kettle should have a thin furnace to economise the fuel used; which is frequently more difficult to be procured than food.

Moreover, lean meat, contains very little nutriment, and hardly any other can be procured on a march. In every point of view therefore, the food for a campaign ought to be previously prepared, where meat of good quality can be procured, and time allowed to prepare it into nutritious food in the smallest compass, and at the cheapest rate.

but I have lost my notes of the particulars. Great benefit in point of nourishment, and improvement in the smoothness of soup, can be derived from linseed, and from gum arabic.

Long continued gentle heat, whether in roasting or boiling (or moderate simmering) renders meat much more tender, juicy, and digestible. A French peasant dines about midday: when his meal is over, he puts into the stew-pan with a close cover, the meat for his next day's dinner; which is exposed to a gentle heat for the 24 hours. A furnace that would hold a gallon of charcoal, and permit the stew-pan to be exposed three-fourths of its depth to the heat of the fire, would be an invaluable present to the poor: and it could be cheaply made at any iron furnace, or any pottery: the common seggar is the thing itself: that is, if it had a rim below to hold the bars for a grate, and a rim above to support the stew-pan. Wood in this country is very dear in the towns, and the extravagance of the back woods is not obliterated in the cities. How often have I seen a quarter of a cord of wood heaped on to boil a teakettle! Such a furnace might be made in a rough way with about five and twenty bricks, so that whatever heat was generated from the fuel, should be applied to the sides of the pot; and this last be protected from the surrounding current of cold air. The inelegance, the inconvenience, the extravagance of an American kitchen is horrible: from the poorest up to the most affluent.

For cookery, whether for the poor or the rich, charcoal at eight dollars the hundred bushels, is cheaper than wood at four dollars a cord. It is more convenient, it is cleaner, it affords the means of expedition, it is more wholesome, it is less fatiguing, it is less hurtful to the eyes. When I come to the kitchen apparatus of a well appointed house, I shall observe further on this.

Sometimes, especially where charcoal is used, it may be a question between saving in point of fuel, and saving in point of food. In some cases of this kind, as where the fuel must be wasted if not used, even broiling may be economical. Generally, however, it may be laid down as an axiom, that where fuel is at a moderate rate, *stewing* is the most frugal, and I believe the most wholesome, and may be made, by far the most palatable method of dressing food.

With respect to *broiling*, or as we term it *barbecueing*, doubtless it is equally extravagant with roasting, so far as the waste of food is concerned; but where the circumstances of fuel admit of it, this method of cooking may occasionally be frugal. In places

where fuel is dear, broiling should be done over a stove supplied with charcoal.

When a poor man purchases meat, the consideration of most moment is not the price per lb., but the relative quantity of meat and bone—next of fat and lean. In point of nutriment, fat is worth twice as much as lean: for candles and soap, thrice as much. Even beef-stakes may be cheaper to a poor man than the cheapest joint of the ox. As to the broiling of a beef-steak, I shall have much to say on the subject when I come to it. For the present, I will only lay down Shakepeare's golden rule; "If when 'twere done, 'twere *well* done, then 'twere well 'twere done *quickly*."

Some experiments have been made by a Mr. W. Scrimshire on the comparative waste in the boiling and roasting of potatoes. Four potatoes were boiled in the usual way, and then steamed to drive off the superfluous water, and render them mealy. They weighed 3562 grains, and lost by the operation when quite cold 80 grains of the original weight, or about two per cent. Another potatoe weighing 1300 grains treated in the same way, lost only 10 grains. The water contained mucilage and extractive matter.

A potatoe of the same kind, weighing 1220 grains, roasted under hot embers, but not sufficiently, lost 200 grains when cold. Another weighing 1198 grains roasted for 1½ hour was found thoroughly cooked, but it had lost when cold 380 grains.

Hence in boiling potatoes, we throw away about 2 per cent. of their weight: in roasting them, about 40 per cent.

The value of the potatoe as an article of culture, is well shewn in the letter of Mr. Curwen, a very spirited and accurate cultivator, and a very well informed and respectable gentleman. I shall subjoin it to this essay, recommending it to the earnest consideration of your readers.

The common breakfast beverage in this country is coffee. I have no hesitation in stating it as a fact, that to a poor family three pounds of dried succory (chicory, chicorium intubus) and one pound of coffee, are of 20 per cent. more value, than four pounds of coffee, and nearly equal in flavour: to me, the beverage is pleasanter. The quantity of the mixture to be used, is about one fourth less than of coffee, to make an infusion of equal strength. Experto crede Roberto. I have frequently drank it. If this be sweetened with molasses made of an inspissated infusion of good malt, it will constitute a saving, that may be an object of some consequence to a poor man with a family. *You* well know that in Northumberland, the poorer people will gladly exchange coffee

for dried chicory, weight for weight. Rye half malted, or even potatoes cut in small pieces, then dried to a chocolate brown, and mixed half and half with coffee, are a pleasant and profitable addition.

The Arabian method of dressing their cuscus-soo, appears to me excellent. In a stew-pan of the size adapted to the family, furnished with a handle that may be taken off at pleasure, to save room in travelling, they put their meat, seasoned with pepper, salt, spices, herbs, sesamum, turmeric, and some rice, with water sufficient to stew it. On the stew-pan, on a rim withinside about an inch below the top edge, rests another stew-pan that fits in close. The bottom of this second or upper stew-pan, is perforated with holes: it is supplied with rice or other vegetables which imbibe and are cooked by the steam of the food below; so that nothing is lost. I do not know a more convenient camp equipage, or a more economical machine for a poor man. I have tried it with full satisfaction.

Good cooking half decomposes, and therefore renders meat more easy of digestion, and of course more nutritious; but this is not *always* an advantage. Labouring people frequently require food that is hard of digestion. It is not an advantage to them that the stomach should be soon empty, or the food pass away too easily. Hence salted meat, and cheese are favourites with them. I have seldom known a delicate female, whose digestion was occasionally bad, and who was occasionally hysterical, that did not require food usually deemed indigestible, such as meat and ham for supper; and with great reverence for the opinions of medical gentlemen, I know of no remedy better for a female, sick headach, or an hysteric fit, than a tumbler full of good hot brandy toddy, with nutmeg and ginger in it. Dr. Cheyne used to say, that a man who had so much regard for his appetite and so little regard for his health, as to eat ham for supper, would not stick to rob on the highway. I do not know that more nonsense has been given to the world in a moderate compass, than by physicians on the article of diet, from the silly remark of Dr. Cheyne, to the grave, common place nonsense of Dr. Willich; whose treatise on diet and regimen, every mistress of a family, ought to consign to her cook to pin on the roasting meat. He deserves a worse family reception, even than Mr. Twiss of notorious memory.

There are some gleams of knowledge in Cullen's Materia Medica, but he theorizes without fact. Whence does he derive his alcalescence of several kinds of meat? He was compelled to say

something, and he said what he could, as learnedly and with as much appearance of scientific theory as he could: but it is very worthless. Darwin knew somewhat about the practical part of eating, and Dr. Sydenham and Dr. Brown (whom I knew in the decline of his life) had discovered from their own feelings, that wine was bad for gout and stone, and that the best beverage was brandy and water. But they were no judges of wine. The common port of an English tavern, is cyder, brandy, elder berries and sloe juice.

But what can, what ought a physician to know profoundly on this subject? Not to speak of some of my living friends to whom the remark will not exactly apply, I should be glad to be informed, what right Dr. Rush, for instance, were he alive, could have to decide on good cookery and good wine? whose hours never his own, could not be encroached upon by the crapulous sensation of too much indulgence! Sober, moderate, abstemious by profession, was *he* equal to give advice on this subject? Those who have been accustomed to good living and indulgence—who occasionally have sojourned amid scanty fare—who have adverted with the attention of a philosopher to the effects on the stomach and the nerves, of good and of bad liquor—who have themselves now and then suffered from occasional excess—and who having lived much in society, have experienced the varieties that plentiful and elegant tables afford—are the only persons qualified to judge. I would rather apply for knowledge of what is wholesome or unwholesome, and what dishes and what wines may be safely indulged in, to the bench of bishops and the bench of judges, to the beneficed clergy and the bar of England, than to the whole host of physicians that the island can muster. I do not like playing with edged tools so near at hand, and therefore I say nothing about the clergy, the bench or the bar of this country.

As to physicians, the clergy of old seem to have been of my opinion, that in cases of intemperance, these gentlemen are not always best qualified to prescribe.

The first case of the gout on record, is related as follows. "And Asa in the thirty and ninth year of his reign was diseased "in his feet, until his disease was exceeding great: yet in his disease he sought not to the Lord, but to the physicians. So Asa "slept with his fathers, and died in the one and fortieth year of his "reign," &c.

The son of Sirach also, has some queer remarks among his praises of Physicians; thus: "Of medicines doth the apothecary

"make a confection; and of his works (qu. Bills?) there is no "end; and from him is peace all over the earth—(that is in the "scripture phrase, I presume, his patients are gathered to their "fathers, and are at rest.)

"He that sinneth before his maker, let him fall into the hand "of a physician."

Adieu: I leave you to study the science of cookery *en chimiste*. As for myself, if I cannot view it *en philosophe*, I will treat it at least *en amateur*. Moderate myself, I do not despise the bird's-eye view of a well spread table, though I can heartily coincide with Horace.

> Si ventri bene: si lateri est; pedibusque tuis, nil
> Divitiæ poterunt regales addere majus.

Observe, however, that Horace does not say simply, *si ventri*, that is if you have plenty to eat; but, *si ventri bene*, that is plenty of food *well cooked*. In my next I hope to peep with good effect, into the kitchens of some of my friends who know how to live.

EPICURI DE GREGE PORCUS.

Mr. CURWEN, who ought to be known under the title of the Northern Patriot, has recently circulated the following letter on the important subject of the culture of Potatoes.

" *Workington-Hall*, *April* 9, 1809.

"SIR,—The improvement of our agriculture appears to me to be the most certain means of advancing the prosperity and happiness of the United Empire, and preserving to us the blessings we enjoy. I may be deemed visionary, but I cannot disguise my opinion, that Great Britain, under a system of good agriculture, would be capable of supporting thirty millions of inhabitants. Nothing can contribute more to this desirable object than the general culture and use of Potatoes.

"The population of Workington is estimated at eight thousand, the weekly sale of potatoes during ten months of the year, exceeds four thousand stone* per week; to supply this consumption requires nearly an hundred acres; I am inclined to believe five times the number of acres would not, in any other mode of

* The common stone is 14lb. So that this is on a calculation of about 400 bushels to the acre, as a common crop: and in England it is so. I insert the next article about BUTTER, because the value of turnip-culture seems perfectly unknown in this country. T. C.

cropping, produce an equal quantity of food. In corroboration of this opinion, let us suppose five hundred acres of wheat, yielding twenty-four Winchesters, per acre, of 60lbs. or six hundred thousand pounds of bread, equal to supplying four thousand persons with half a pound of bread for three hundred days. The consumption then would be half a pound of bread to four pounds of potatoes. The comfort derived from the use of potatoes by the working classes, affords a most powerful argument in favour of their general introduction—no food is more nutritious, none so universally palatable. The philanthropist and politician will equally promote their views, by extending the use and culture of the potatoe.

"For eight years past I have fed all my working horses upon steam potatoes, mixed with cut straw, and latterly I have with equal success given them to oxen. They would answer for milch cows, and fattening cattle, if they could be raised at less expence. My consumption for eight months in the year is a ton and a half per day, or about three hundred and sixty tons annually—the land used, in feeding with potatoes as a substitute for hay, is between a sixth and a seventh—fifty acres of potatoes will furnish above the quantity required, whilst three hundred and fifty acres of hay would most frequently fall short of supporting the same number of working horses and oxen—the advantage of this system extends beyond the individual, and is felt both immediately and remotely by the mass of the community. In the first place, the ground heretofore indispensably requisite for the growth of hay, for horses is now applied to the purposes of a dairy, and in the last year 507,024 quarts of milk were sold, whereas in 1804, only 222,755. In years of scarcity, the food of horses can be applied to the use of man.

J. C. CURWEN."

BUTTER.

SEVERAL specimens of Swedish turnip butter, from the dairy of Mr. Ives, of Catton, were exhibited at the principal inns in Norwich, on the 15th of April; and being placed on the dinner tables at each house, gentlemen had a fair opportunity afforded them of pronouncing a decided opinion upon its quality.

It has afforded a convincing proof, that turnips of all descrip-

tions, do not universally, in a greater or less degree, injure the flavour of our milk and butter; to this assertion, the Swedish turnip is an exception, in a most decided point of view.

It appears, that the management of these cows is most simple and easy; they are fed on hay, good oat-straw, and Swedish turnips; but it ought to be observed, that a degree of care and neatness is necessary in preparing these turnips for them. In the first place, they are drawn about the end of February or beginning of March, laid in ridges or heaps of a load or two each, and left on the land for two or three weeks; they are then carted away to some convenient place, their tops and tails cut off clean, and piled on a heap, where they are kept as free from soil or dirt as possible. It is adviseable also, that the operation of topping and tailing be done in a yard apart from that where the cows are fed; for should they eat any of the tops, this excellence of flavour in the milk and butter will be deteriorated considerably. The mode of preparing these turnips deserves particular attention. The drawing them from the land at the time they are in their most compact state, then depriving them of the absorption, if it may be so called, of the new or vernal sap of the soil, a diminution of that important matter does not take place, as from an opposite course of management would be the result, to the no small injury of the following crop. In this state too, they keep much longer; and, moreover, which is of no less importance, the turnips are, in themselves, more nutritive, as would appear from the superior quality of the butter produced; for, by being thus exposed to the air, and detached from the soil, a considerable portion of aqueous moisture is carried off by natural evaporation, which would otherwise add to the quantity of our dairies, but not the quality, as we find to be the case in feeding cows with those which have been recently drawn. *Month. Mag. June* 1809.

TABLE.

From Professor Davy's Treatise on Agriculture, p. 131.

Table of the quantities of soluble or nutritive matters afforded by 1000 parts of different vegetable substances.

Vegetables or vegetable substance.	Whole quantity of soluble or nutritive matter.	Mucilage or starch	Saccharine matter or Sugar.	Gluten or Albumen.	Extract, or matter rendered insoluble during evaporation
Middlesex wheat, average crop	955	765	—	190	
Spring wheat - -	940	700	—	240	
Mildewed wheat of 1806	210	178	—	32	
Blighted wheat of 1804	650	520	—	130	
Thick-skinned Sicilian wheat of 1810	955	725	—	230	
Thin-skinned Sicilian wheat of 1810	961	722	—	239	
Wheat from Poland -	950	750	—	200	
North American wheat	955	730	—	225	
Norfolk barley - -	920	790	70	60	
Oats from Scotland -	743	641	15	87	
Rye from Yorkshire -	792	645	38	109	
Common bean - -	570	426	—	103	41
Dry peas - -	574	501	22	35	16
Potatoes - -	from 260 to 200	from 200 to 155	from 20 to 15	from 40 to 30	
Linseed cake - -	151	123	11	17	
Red beet - -	148	14	121	13	
White beet - -	136	13	119	4	
Parsnip - -	99	9	90		
Carrots - -	98	3	95		
Common turnips -	42	7	34	1	
Swedish turnips - -	64	9	51	2	2
Cabbage - -	73	41	24	8	
Broad-leaved clover	39	31	3	2	3
Long-rooted clover -	39	30	4	3	2
White clover -	32	29	1	3	5
Sainfoin - -	39	28	2	3	6
Lucerne - -	23	18	1	—	4
Meadow fox-tail grass	33	24	3	—	6
Perennial rye grass -	39	26	4	—	5
Fertile meadow grass	78	65	6	—	7
Roughish meadow grass	39	29	5	—	6
Crested dog's-tail grass	35	28	3	—	4
Spiked fescue grass -	19	15	2	—	2
Sweet-scented soft grass	82	72	4	—	6
Sweet-scented vernal grass	50	43	4	—	3
Fiorin - -	54	46	5	1	2
Fiorin cut in winter	76	64	8	1	3

All these substances were submitted to experiment green, and in their natural states. It is probable that the excellence of the different articles as food will be found to be in a great measure proportional to the quantities of soluble or nutritive matters they afford; but still these quantities cannot be regarded as *absolutely* denoting their value. Albuminous or glutinous matters have the characters of animal substances; sugar is more nourishing,* and extractive matter less nourishing, than any other principles composed of carbon, hydrogen, and oxygen. Certain combinations likewise of these substances may be more nutritive than others.

I have been informed by Sir Joseph Banks, that the Derbyshire miners in winter, prefer oat cakes to wheaten bread; finding that this kind of nourishment enables them to support their strength and perform their labour better. In summer, they say oat cake heats them, and they then consume the finest wheaten bread they can procure. Even the skin of the kernel of oats probably has a nourishing power, and is rendered partly soluble in the stomach with the starch and gluten. In most countries of Europe, except Britain, and in Arabia, horses are fed with barley mixed with chopped straw; and the chopped straw seems to act the same part as the husk of the oat. In the mill 14lbs. of good wheat yield on an average 13lbs. of flour; the same quantity of barley 12lbs. and of oats only 8lbs.

In the south of Europe, hard or thin-skinned wheat is in higher estimation, than soft or thick-skinned wheat: the reason of which is obvious, from the larger quantity of gluten and nutritive matter it contains. I have made an analysis of only one specimen of thin-skinned wheat, so that other specimens may possibly contain more nutritive matter than that in the table.

STEAM ENGINES.

SINCE concluding this article, a few pages back, new communications induce me to resume it.

I have already mentioned, that on a rail-way near Leeds in Yorkshire, in England, a waggon containing a steam-engine, drags after

* This may be: so thought Cullen; but I know of no experiments to prove this. T. C.

it twenty waggons, each containing three tons of coal, at the rate of four miles an hour. I find, that steam applied to draught carriages, has been used for some years in England, and the practice is extending.

It is with very sincere satisfaction, I announce, that several gentlemen of considerable mechanical abilities, in our own country, are now turning their attention to the improvement and construction of steam engines. Several drawings have been sent to me for opinion and publication, but at present, I can do no more than briefly notice the principles adopted.

In *Mr. Fulton's* engines, the method of packing the piston, of preserving the prependicularity of the stroke, of communicating the rotatory motion, and the form and dimensions of the unwieldy working beam, have been improved, since my time of observation.

Mr. French, of New York state, is also constructing engines, with some improvements on Boulton and Watt's, as I have heard, but I do not know exactly what the alterations are.

Mr. Oliver Evans's establishments in Philadelphia and at Pittsburgh, have early and greatly contributed to bring steam engines into use, but I do not accurately understand the point on which his claim to a patent right, is meant to rest. If I had the precise invention explicitly described, I should be glad to give it that currency, to which its novelty may entitle it.

Mr. Rodman, of Washington, South Carolina, has sent me the drawing of an atmospheric engine, working with two cylinders, which appears to possess considerable merit, as to the simplicity and consequent cheapness of the machinery. I do not remark any contrivance to preserve the perpendicularity of the stroke. The construction and situation of his valve, I understand, is much like the method adopted by Mr. French: but about this I am not able to speak with accuracy.

Mr. Ogden, of Pittsburgh, is also engaged on a steam engine, with two cylinders contiguous to each other. He proposes working his steam of whatever density, in two cylinders, to be stopt off at any point. If at one half, the instant one cylinder is half filled, its steam valve is closed, and the steam valve of the other is opened. On the first pistons arriving at the end of its stroke, that of the other cylinder will have performed half a one. Its steam valve will then be closed, and that of the first again opened, as well as its opposite condensing valve: in this manner the motion will be

regularly continued, each cylinder being alternately half filled with steam.

The pistons act simultaneously, at right angles with each other, and one is at its maximum when the other is at its minimum, so that there is no necessity for a balance wheel as a reservoir of power: for when one piston ceases momentarily to act, the other instantaneously continues the motion in the same direction. The power is communicated to crank wheels worked by shackle bars attached to each piston. If the steam be stopt off at one half, and left to act by its expansive force, the gain is half a cylinder full of steam at each stroke. There is nothing new in two cylinders, or in working by expansive steam, but the getting rid of the balance wheel by the simultaneous action of each piston in the manner above described, I *think* is new.

Mr. Latrobe of the same place, is erecting a manufactory for steam engines, in which he proposes to make some improvements on the construction of Boulton and Watt: but whether to be used solely for water navigation, or for sale, I know not yet.

So much exertion, and by such men, affords ground to hope that at no distant time, improvements may take place, that will put our Engineers of America, upon a par at least with those of England. But of all the attempts to vary from the common construction, I have seen none that promises so well, as those of Mr. *Dowers* of Philadelphia. I have carefully examined his drawings, and I think he has skilfully combined a series of improvements, that if put in practice, with great attention to mechanical accuracy, will go near to supercede every variety of steam engine now in use. These improvements contemplated for a double engine, consist in

1st. A more perfect mode of condensing, by the *joint* application of exposing a large and thin metallic vessel containing the steam, to the action of cold water, as the Rev. Mr. Cartwright proposed——and the common method of condensing by injecting the spray of cold water. A plan nearly similar to Mr. Dowers' condenser, is suggested, p. 82 of this Volume.

2ly. Using perpetually the same water, for the boiler, the condenser, and injector; without diminution or the necessity of addition; except what may arise from imperfections in the workmanship of the vessels. In which it is not easy, always to guard against steam leaks, and water leaks. The wormanship being good, this engine must work with a smaller supply of water than any other yet known.

5ly. A more certain mode as I think of discharging the air. It arises to the top of the water, and is thrown out by the valves that open with the upward stroke of the piston that throws the cooled water into the condenser.

4ly. A new, and seemingly effectual method of keeping the water at a regular height in the boiler, by making the condenser discharge any surplus into the boiler.

5ly. Saving and condensing the steam occasionally discharged from the boiler, and which in other engines escapes into the air, so that the boiler and condenser being once supplied with water, this stock of water is not diminished by waste steam, or encreased by extraneous injection water: or varied, except as need may arise from causes depending, not on the principle of working the engine, but from accidental and unavoidable imperfections and wear in the materials and workmanship, or perhaps from slight decomposition of the water itself.

6ly. Boilers on a new, and if the workmanship can be depended on, an improved construction: not much differing in principle, but greatly in form and arrangement from those hitherto employed: being two large boiler-cylinders through which the fire flue runs, and which are furnished with a series of pipes, and one small boiler-cylinder in the centre, over which is a cylindrical reservoir for the steam.

7ly. A rack, or cog-wheel with a handle, by which the ears or plugs, of the plug beam, may be moved and varied at pleasure; so as to *regulate* as need may require, the opening of two steam-valves, additional to the valves of the common engine: and by this means, to stop off the steam at any given point or portion. In Watt's engine this is managed by a pin. By means of this regulator, if a fourth part only for instance, of the cylinder full, be thrown in, it can act by its expansive force. So that no steam need be employed, beyond what is necessary to the required work of the engine. The regulating valves, are on a construction different from the common valves, being worked by rods, one within the other. The steam admitted, is also admitted at once, not gradually; which last practice although recommended by Woolf and now common (see p. 186 of this vol.) has disadvantages.

8ly. A new method of *augmenting* the force of steam, by exposing to considerable heat, a part of the steam that acts on the piston, and mixing it with the steam that proceeds direct from the boiler. Compare this with Mr. Woolf's patent, page 190 of this volume.

9ly. A method of superceding the necessity of a fly wheel, by means of two circular crank and cog wheels attached by shackle-bars to the pistons of two cylinders. The crank wheels are cast in the same mould, and move a smaller cog wheel in the centre; so that, when the piston in one cylinder has arrived at the bottom, the piston in the other, is just commencing its descent, and vice versa. The combined force of the pistons in each cylinder, being always the same. Here, no reservoir or accumulation of surplus force in a fly wheel, is necessary to carry the motion past the perpendicular pressure; because, the instant one of the pistons with its attached crank wheel, has spent its force on the middle cog wheel, the other piston with its attached crank wheel, begins to act; driving round the centre cog wheel in a similar and uniform direction. The two large wheels between which the smaller is placed, are connected together by a small beam or brace. This invention is contested by Mr. Ogden; and with the dispute, I have nothing to do. It is worth while however, to compare it with Mr. Cartwright's method of communicating rotatory motion; see p. 84 of this volume.

Mr. Dowers' proposes making the valves of the common engine, answer the purpose of his regulating valves. If so, so much the better. There are practical difficulties attending the construction of the boiler, and the augmenter; but they are not insuperable.

If alcohol or ether, or any mixture of alcohol and water, can be used economically in steam engines, as good judges think may be done, this engine will afford the means of using it. But I know of no decisive experiments yet made on this important subject. Mr. Dowers, and I, in my laboratory, past whiskey diluted with from one half to two thirds water, through a red-hot gun barrel, but the gas produced, was small in quantity and not inflammable. It was in fact no more than the air contained in the gun barrel.*

The wasteful and unscientific practices of using steam little higher than to afford mere atmospheric pressure thus neglecting the force to be gained by a small addition of fuel†——and of gene-

* The inside however had been previously oxyded.

† It is surprising that Mr. Watt who first discovered and demonstrated (see p. 93, and 171 of this volume) that the elasticity of steam being in proportion to its density, its expansion when stopt off at 1-4th, 1-3rd or 1-2 the capacity of the cylinder will produce a power in a much greater ratio than 1-4th, 1-3rd or 1-2 of the whole, should have made so little use of this discovery in his steam engines. The time is approaching when steam of great

rating steam of high temperature and great expansive force, to waste itself in the open air, and in its exist to be counteracted by the resistance of the atmosphere, are thrown aside. The faults both of the European and the American engines, are in a great degree obviated; and we may expect from American ingenuity, a more perfect engine than has yet been devised.

The engine in contemplation, will act by steam at high temperature, as Watt suggested, and Trevethick practised on a large scale: it will act by expansive force as has long been the practice in many English engines; and by two cylinders: so as to combine the modern improvements, and obviate modern defects. How far Mr. Dowers has been indebted, if at all, to his predecessors, the readers must judge by the references I have made to former pages of the present volume.

I shall indeed rejoice to see some American by and by, still improve upon his ideas. T. C.

NOTICES.

Stone Coal. Judge Gibson, of Luzerne, has written me the following letter.

Wilkesbarre, February 23, 1814.

Dear Sir,

I send you a likeness of one of your friends. There is nothing remarkable in it, except that it is done with the *stone coal* of this place, instead of Indian ink. It is prepared for use by rubbing a bit of it on a fine hard stone in gum water, just thick enough to hold the particles in suspension; it is then laid on in the usual way with a camel hair pencil. By comparison with a drawing in

force will diminish the size of boilers; when unwieldy beams and ponderous fly wheels will be disused; when single engines will give place to double, when expansive power will be used to the utmost; and when no steam will be generated to be thrown away. As yet, I dare not anticipate the time, when water will be laid aside, and alcohol, ether, alkaline gas or hydrogen be substituted in its place. Alcohol and ether are condensible at low temperatures——Ammoniacal gas by the vapour of muriatic acid——and hydrogen by fixing it with oxygen, and converting it into water. These are speculations; and so was at one time, the steam engine itself. T. C.

Indian ink, you will, I doubt not, give the preference to the coal, as it will be found free from a brownish cast, always perceivable in the former. The harshness observable in the inclosed drawing arises from the extreme badness of the pencil I was obliged to use, and not from the quality of the ink, which is susceptible of the greatest softness.

The coal is found to be superior to lamp or ivory black for paint, printers ink, and blacking leather. It also makes the best writing ink for records that has yet been discovered. The colour is deeper, and is not in the least affected by the oxy-muriatic acid, or any other chemical agent, and must remain unaltered by time. The application of coal to these purposes was discovered by Mr Jacob Cist of this place—he has obtained a patent.

Very sincerely your friend,

JOHN B. GIBSON.

Thomas Cooper, Esq.

The only objection to the preceding account of the uses to which stone coal may be put, is, that whatever mucilaginous substance be used to fix it on the paper, water can wash it away. But that it will afford a colouring matter unattackable by any acid, and unalterable by any time, cannot be doubted. The discovery is of importance. T. C.

Platina. Dr. Bollman, whose ingenuity and perseverance upon this subject deserves well of the public, has succeeded in giving a plating of platina to iron, of which I have a specimen. Also I believe to copper. The use of this metal will be extended to many manufactures.

He has succeeded in giving the mercurial-coloured metalline coating to porcelain with platina. He will by and by introduce it into the glassworks, if not in the form of crucibles (which can be done) at least to furnish an unoxydable smooth plate, on which the glass blower can work his vessel. It promises, in his hands, to become a very important object to the useful and ornamental arts.

Statistics. The following table has been inserted in two or three of our daily papers. The last number of the sixth column has been printed 16,452,656. This must be a mistake. I have inserted six instead of sixteen, for reasons obvious on inspection. In my former number, I stated, by conjecture, the poor rates of Great Britain at six millions sterling, in round numbers. I was about half a million too low.

British Statistics. The following table, exhibiting a concise and striking view of the internal condition of England, is extracted from a British paper of 16th October, 1813.

A TABLE

Exhibiting at one view the depreciation of our currency, the disproportion between the advance made in the price of labour and the fall which has taken place in the value of money; with its consequent progressive pauperism, from the revolution of 1688 *to the year* 1812.

Years.	Price of bread.	Value of the pound in quartern loaves.	Average money wages of husbandry labor.	Bread wages in quartern loaves.	Poor rates.	Number of Paupers.
1687	3*d*	80	6*s*	24	*l.* 665,362	563,964
1776	$6\frac{1}{2}$	37	8	15	1,523,163	695,177
1785	6	40	8	16	1,943,649	818,851
1792	7	34	9	15	2,645,520	955,326
1803	10	24	10	12	4,113,164	1,039,716
1811	12	20	12	12	5,922,954	1,247,659
1812	20	12	15	9	6,452,656	2,079,432

This is not inconsistent with the account I have given in page 251 of this volume.

The peck loaf ought to weigh 17 lb. 6 oz. Therefore the quartern loaf ought to weigh one fourth of this, or 4 lb. $5\frac{1}{2}$ oz. Every sack of flour is to weigh $2\frac{1}{2}$ cwt. net weight, or 280 lb. and out of this ought to be made 20 peck loaves. When the price of grain rises, the magistrates who set the assize of bread, allow the quartern loaf to be diminished in weight. Fine wheaten bread, is allowed to weigh but three fourths only of the weight required for household bread.

The following table is from Niles's Register.

COMPARATIVE STATEMENT

Of the Population and Land Forces of different states at present engaged in the war.

Names of the States.	Population.	Land Force.	Remarks.
			or about
Empire of Great Britain	16,531,000	306,760	1 in 54
Russia	42,218,000	560,000	75
Austria	20,216,000	320,000	63
Kingdom of Prussia	4,984,877	250,000	20
Sweden	2,326,000	45,000	44
Spain	10,396,000	100,000	104
Portugal	3,550,000	30,000	118
Sicily	1,656,000	10,000	165
Duchy of Warsaw	3,774,462	30,000	126
Total	105,601,339	1,651,760	764
Deduct for troops indisposable (indisposable en Francoise) from			
Great Britain 150,000			
Russia 260,000			
Austria 100,000			
Prussia 50,000		560,000	
Remain	105,601,339	1,091,760	
Empire of France (including all the new departments	42,316,000	590,000	1 in 7
Kingdom of Italy	6,719,000	40,000	16
Kingdom of Naples	4,964,000	16,000	31
Republic of Switzerland	1,638,000	15,000	10
Confederation of the Rhine	13,560,120	119,000	11
Kingdom of Denmark	2,509,600	74,000	3
United States of America	6,800,000	20,000	32
Countries not included in the above			
Part of the country of Katzenelubogen	18,000		
Principality of Erfurth	50,330		
Illyrian Provinces	110,000		
Total,	78,385,050	874,000	89
Deduct for troops indisposable from France		190,000	
Remain	78,385,050	684,000	
Balance in favour of the allies	27,206,289	407,760	

It is mentioned as a remarkable event, that within these three weeks there has been more new accounts opened at the bank of England, than there has been for the four preceeding years, principally by foreigners. *London paper.*

British Revenue. An official account laid before the house of commons, states the amount of the net produce of the permanent taxes in Great Britain for the year ending the 25th of October, 1812, at 38,743,428*l.* 16*s.* 8¼*d.*; and for the year ending the 25th of October, 1813, at 37,833,366*l.* 12*s.* 1½*d*,; being a deficiency of about 900,000*l.* The same account states the total amount of the net produce of the war taxes, for the year, ending the 25th January, 1812, at 21,822,532*l.* 14*s.* 10¼*d.*: and for the year ending the 25th October, 1813, at 22,740,568*l.* 4*s*, 0½*d.*; being an increase to about the amount of the deficiency in the permanent taxes. Thus the net produce of the public revenue of Great Britain, for the year ending the 25th of October, 1813, is 60,573,934*l.* 16*s.* 2*d.*

To 60,573,934*l.* add the poor rate 6,452,656 the amount will be 67,026,590*l.* sterling levied on the country, beside tythes and other ecclesiastical sources of taxation.

In 1812, the income tax was considered as somewhat short of 18 million, including arrearages due. At ten per cent. this would be levied on an estimated income of 130 millions. Hence, on the average, every man in Great Britain, pays one half at least, of his income in taxes. I do not want to be perpetually harping on foreign commerce, and the wars it induces, but surely it well deserves to be considered, how much of this enormous taxation can fairly be imputed, directly or indirectly to that source.

I meant in the present volume to have given an account of French statistics. I shall remit that, till the publication of Mr. I. T. Naylor's book.

So of the United States statistics, I shall be able to give a better view of this subject, after the recess of congress and our state legislatures.

Dyeing. My booksellers hasten to inform me, that a translation of Berthollet on dyeing is about to be published. Also a new edition of Dr. Bancroft's book on that subject. No one has done so much to elucidate the theory of dyeing as Berthollet and his son. Dr. Bancroft's experiments, though principally made (at least in his first volume) to extend the sale of his quercetron bark (the bark of the black oak *quercus nigra*) are of importance. I expect something from the new edition. I think all persons interested in the art of dyeing, will purchase both books. But when I come to that article, which I may probably treat of earlier than I at first intended, I shall endeavour to make it the interest of persons concerned in the art of dyeing to purchase also the Empo-

rium that contains it; but I am not anxious hastily to publish my collections, for fear that many if not most of the facts and processes may be forestalled by these proposed publications. I hope to make that article when I come to it, a good one; which I cannot, without looking at the latest sources of information. T. C.

Potatoes. I consider the paper of Mr. Curwen on this subject, so fully corroborated, and in a manner so very different, by the experiments of Professor Davy, as very impertant. If an acre in potatoes yields but *twice* the weight of produce, as an acre in wheat, it affords an equal weight of nutriment. But an acre in potatoes equally well managed, will afford near *twenty times* the weight: nor is there great difference in the expence of cultivation; for potatoe ground highly manured, is the very best preparation for a wheat crop. In my neighbourhood in Lancashire and Cheshire, potatoes (when an early and a late crop were raised for the Manchester market) would justify twenty pound sterling, a Lancashire acre (about $\frac{1}{3}$ more than a statute acre) in manure. The inferences in respect of national as well as individual saving from the facts stated, are of the very first moment. T. C.

Lightning. The following cautions respecting the danger that may occasionally arise from lightning, are sufficiently obvious, but they deserve to be frequently brought into notice. T. C.

In storms of this kind we are frequently, from inadvertence, exposed to imminent danger, when a timely, and in general a very practicable, mere change of station would secure us against it.

It has been long known that the cause of thunder, is the same with that which produces the ordinary phenomena of electricity; thunder being no other than a grand species of electricity, or, rather, that electricity in the hands of man is a feeble imitation of thunder from the hand of the Almighty. A thunder-cloud may be considered as a large conductor, actually insulated and surcharged with electric matter; which, should it meet with another cloud not electrified, or less so than itself, will discharge part of its subtile fluid into the latter, by flashes of lightning and formidable reports of thunder; until an equilibrium of quantity be restored.

Whether this principle, the electric fluid, actually emanates from the sun, and commixes with our atmosphere, as some philosophers conceive; or whether it is a principle inherent in the earth and its appendages, *per se*, is a question not necessary to be

here discussed: certain it is, that we find it abundantly diffused through the atmosphere, and on the surface of the earth, and on various bodies attached to the earth: we know also that some kinds of bodies will convey this fluid with greater facility than others will. Such bodies as most readily convey it from object to object, are called conductors: the most common of which are all metals, in the following order of perfection; gold, silver, platina, brass, iron, tin, and lead; metallic ores, the fluids of animal bodies, water, ice, snow, green wood, and most earthy substances. There are other bodies which will not, without difficulty, conduct it; and which, on that account, are called non-conductors: such are glass, sulphur, resin, silk, cotton, feathers, wool, hair, paper, ashes, and most hard stones.

From hence it may be inferred that, in dangerous thunder weather, we should carefully avoid standing or sitting in contact with any of the conductors.

By dangerous thunder weather, I mean such storms as are over our heads or near to us. The distances of which may be nearly ascertained, by the known progress of sound through the air, which is at the rate of about 381 yards in a second of time; so that if there are nine beats of a clock, or ten of the pulse of a person in health, between a flash of lightning and the report of thunder, the distance is then about two miles, and no danger is at hand; but if no more than about four beats of a clock, or five pulsations, are between them, danger may be apprehended, and precaution should be taken.

In the open air, standing under tall trees, especially such as have dead or dry branches, or against very lofty buildings, is dangerous.

As lightning runs swiftly along, or plays amongst metallic bodies, let care be taken to avoid all such, whether out of doors or within.

All doors and windows of apartments should be set open, that lightning may have free passage through.

A sitting or recumbent posture on chairs, mattresses, couches, or beds, filled with hair, wool, or feathers, in such part of a room as may be out of the influence of conductors, or may not be in the way of any current between windows and doors, is, undoubtedly, the safest situation that can be chosen.

The furniture of the fire-place should be carefully avoided.

So, also, should the wires and cords of bells.

Picture-frames, and other furniture gilt, are unsafe to stand close by. A most remarkable effect of lightning, in gilded rooms happened in the hotel occupied by Lord Tilney, at Naples, in the

year 1793. The apartments were decorated with great elegance, as was the taste of persons of rank in that country: the cornices of the room were gilt, in the Italian manner, from whence proceeded a number of plat-bands, serving as frames to the tapestry, gilt likewise; so also were the borders of the pannels of the wainscot, the frames of pictures, mirrors, and door posts.

On the 24th of March, Lord Tilney had a numerous party at dinner. A loud clap of thunder alarmed the company, and in an instant the whole apartment seemed to be on fire. Every one thought himself struck by the lightning; but, to their great joy, no one was wounded; for the prodigious quantity of metal conductors enabled the lightning to pass, without injuring any one.

On examination, it was found that great part of the cornices were damaged, particularly at the corners, and where bell-wires passed through; picture frames much injured; and some of the bell-cords burnt.

By these facts, we have clear testimony that the electric fluid most readily attaches itself to metallic conductors; which in this instance, were the means of saving the company from destruction; had any of them, at the time, been in contact with these gaudy trappings, it is probable that their lives would have been the sacrifice. A. C.

Cloaths catching fire. Muslin dresses and silk stockings, with midnight dances, have set the consumption at the head of all disorders in point of frequency and mortality.

Muslin dresses, and open fire places, have destroyed many a valuable and much lamented female, by the most painful of deaths. There are one or two plain, common-sense remarks that deserve to be borne in mind.

Fire will consume a piece of muslin placed over it, much more rapidly than one placed on the same horizontal line or plane. The instant a female finds the fire has caught her cloaths, she should throw herself down, and cover herself with the carpet, or the woollen cover of a table; the very position alone, will afford time to extinguish a moderate flame, even without a carpet.

If a person be near, the fire may be extinguished, by turning up and folding up in a tight roll the garment that has caught fire. T.C.

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